VOLUME 61 [W. B. No. 1101] NUMBER 4

MONTHLY WEATHER REVIEW

APRIL 1933

CONTENTS

UNITED STATES DEPARTMENT OF AGRICULTURE

WEATHER BUREAU

WASHINGTON, D.C.

For sale by the Superintendent of Documents, Washington, D.C. - - - - - - - - - - - - - - - See page 4 of cover for prices

CORRECTIONS

Volume 61, January 1933, page 4: Table 2, fourth box head, "No. 245" should be "No. 255."

Volume 61, February 1933, page 46: In second column, first paragraph next to last line, "1927" should be "1923."

MONTHLY WEATHER REVIEW

Editor, W. J. HUMPHREYS

Vol. 60, No. 4
W. B. No. 1101

APRIL 1933

Closed June 3, 1933
Issued July 12, 1933

THE 11-YEAR SUN-SPOT PERIOD, SECULAR PERIODS OF SOLAR ACTIVITY, AND SYNCHRONOUS VARIATIONS IN TERRESTRIAL PHENOMENA

By H. W. Clough

[Arcade, N.Y., April 1933]

SYNOPSIS

This paper supplements a former one with corrections and additional matter. A few changes are made in the Fritz epochs of "probable maxima" of sun-spots, dating from 300 A.D., and it is shown that the frequency distribution of the 11-year sun-spot intervals derived from the ancient epochs has about the same mean, skewness, and dispersion as that of the Wolfer intervals from 1610. For the whole period of 1,600 years the most frequent interval or mode is computed to be 10.94 years while the normal length of the period computed by a least-square method is 11.067 years. The mean deviation from 11.0 years is ±1.69 years.

By appropriate statistical processes and criteria, the sequence of the 11-year intervals is shown to be systematic rather than fortuitous. While the most frequent interval between peaks or hollows in a random sequence is the two-interval, there is a marked tendency for maxima or minima in the solar curve to recur about every third interval. In other words the most frequent interval of recurrence is about 36 years.

The epochs of maximum and minimum length of the 11-year period, derived from the curve of 11-year intervals, yield by the least-square computation a normal length of 37.5 years for the long period, with an amplitude of 2.4 years. On eliminating the 37-year period by an appropriate smoothing of the 11-year intervals, a still longer period is disclosed with a normal length of about 83 years and an amplitude of 1.5 years. Further smoothing discloses a 300-year period with an amplitude of 0.5 year. The 300-year period undergoes a long secular variation in length, roughly estimated at 1,400 years.

Both the 37-year and the 83-year periods undergo a 300-year variation in length, comparable with that of the 11-year period, the maximum lengths being about twice the minimum lengths.

These three periods exist also in the relative numbers and the ratios, $a:b$, that is, time of increase to time of decrease of sun spots from minimum to minimum, the numbers varying inversely and the ratios directly with the length of the 11-year period.

These periods are apparent not only in auroral data but in various other terrestrial data—frequency of severe winters, frequency of Chinese earthquakes, flood and low stages of the Nile, tree growth in Arizona and California, and wheat prices in England.

The epochs of maxima of the three periods lag somewhat behind the epochs of maximum solar activity, and the amount of the lag is proportional to the length of the period. The lags of the 37-year and 83-year epochs exhibit a 300-year period, also a long secular variation—the lag after 1,000 A.D. being about two thirds that previously.

INTRODUCTION

In a former paper (1) I discussed the so-called "Brückner meteorological cycle" of 35 years and showed that a similar variation could also be traced in certain solar data. This indicated that the Brückner climatic cycle probably is of solar origin. A 300-year period was also shown to exist in the data. The present paper supplements the one just mentioned, corrects an error in the ancient epochs, gives additional evidence for the 35-year and 300-year periods and new evidence for the existence of two periods of around 83 years and 1,400 years in both solar and terrestrial data. It deals mainly with new results and the reader should refer to the former paper in order to have a clear comprehension of some of the details. Others of my papers contain material which will be referred to either as results previously obtained or as discussions of methods employed in the present paper.

As to the truth of the conclusions offered, it may be stated that, while the individual steps leading to the final results have varying degrees of validity due to the inherent inexactness of the data, by the smoothing processes and graphical methods employed inaccuracies can largely be detected and eliminated. The validity of the whole body of evidence rests upon the mutual consistency of its separate elements.

THE 11-YEAR SUN-SPOT PERIOD

The unbroken continuity of the 11-year sun-spot period is a fundamental concept in this investigation. If it can be shown that this period has existed continuously, although with variations in length, for an indefinite duration, the reasonable inference is that other solar periods may be equally continuous and persistent over long intervals.

My early paper contained a discussion of the ancient epochs of sun-spot maxima derived by Fritz from early auroral data and the Chinese observations of sunspots. His paper was translated and published in the Monthly Weather Review, October 1928 and readers should refer to it in connection with the following discussion.

A careful examination of Fritz's tables—1, Sun-spot epochs; 2, Auroral epochs; 5, Probable maxima—has led me to make a few changes in his epochs of maxima. The Fritz, Lovering, and Short catalogs of auroras were examined for possible additions or discrepancies. From

the Lovering catalog were obtained four additional years of auroral displays, near the probable dates of epochs missing in the Fritz list, viz, 629, 752, 1039, 1499.

There are at least two cases where the solar data seem doubtful. During the years 535–536 the sun had diminished brilliancy for 14 months, and in 626 the sun was partially darkened for 8 months. Fritz regarded 538 as a probable maximum, based on 535 as a solar epoch and 540 from auroral data. I reject the year 535 and regard 540 as the probable epoch. He regarded 625 as a maximum, based on 626 as a solar and 624 as an auroral epoch. I reject 626 and advance the date of the epoch to 629, the date of an aurora in Lovering's catalog. The year 657 is regarded as a maximum epoch by Fritz, being a mean of two aurora years, 654 and 660. However the year 660 is not given in either of the two large catalogs and I have therefore regarded 654 as the more probable date.

As a result of these changes, instead of one epoch between 512 and 538 and one between 538 and 555, I insert two between 512 and 540 and none between 540 and 555, and instead of three epochs between 616 and 657 I assign only two epochs between 616 and 654.

Some discrepancies and errors have been found in Fritz's tables. He omitted a few epochs from table 5 which seem clearly evident from table 2, namely, 479, 488, and 879. The epoch 1280 appears in table 5 but not in table 2, while 388 appears in table 1 but not in table 5. In table 1, 1547 is a sun-spot year, while 1549 is given as the maximum. Assuming 1547 to be the correct date, the probable maximum in table 5 is more likely 1548.

After 388 only four epochs are based solely on sunspot observations. I have changed a few epochs, giving greater weight to two or more adjacent years with aurora than to a single year with sun spots. Such epochs are 870, 970, 1204, and 1604 instead of 872, 972, 1203, and 1603. The epoch 360 has been changed to 361 to make the interval from the preceding epoch 7 years instead of 6, which is an improbably small interval.

The epochs remaining for which no data exist have been inserted at nearly equidistant intervals between the epochs derived from observational data. The finally adopted epochs, with the supplied epochs indicated by an asterisk, are given in table 1, together with the Wolfer epochs of maxima. The 11-year intervals are given in column 2 and are shown plotted in figure 1 on their mid-dates.

Evidence as to the accuracy of these epochs is afforded by their recurrence in nearly the same sequence after an interval of 1,184 years. This interval is 107(11.066), 32(37.0), 14(84.5), 4(296). It is therefore a nearly exact multiple of three periods, which will be discussed below, and is approximately a long secular variation. Adding this interval to the epochs in table 1, beginning with 301

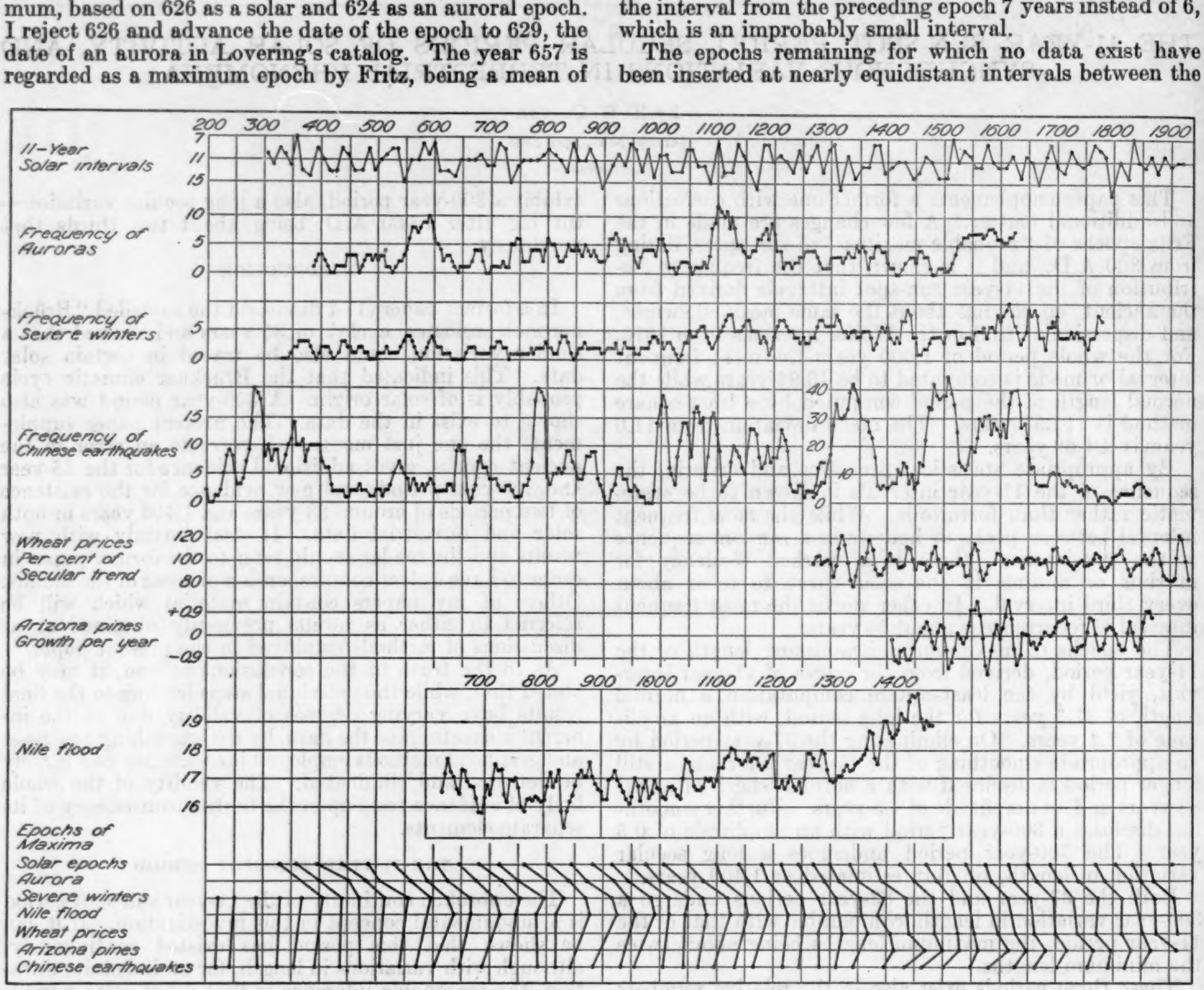


Figure 1.—The 37-year period in various solar and terrestrial data. Epochs of maxima are plotted below and joined to show interrelations and lags.

and ending with 742, there results a series of dates which coincide closely with the observed epochs. The mean deviation of the computed from the observed epochs is ±1.78 years, and 90 percent of the deviations are within the limits ±3 years. Now the average deviation from 11.1 years of the intervals between maxima from 1615 to 1928 is ±1.61 years and 85 percent are between 8.1 and 14.1 years. *Thus a prediction of a maximum epoch made by adding 1,184 years to the somewhat uncertain early epochs is nearly as accurate as one made by adding 11.1 years to the relatively exact epochs since 1615. Such a result confirms in a striking manner the general accuracy of the ancient epochs and the reality of the various solar periods.*

Frequency distribution of the 11-year intervals.—The frequency curve of the 11-year intervals shows a slight positive skewness. Omitting the long 17-year interval, the 55 Wolfer intervals yield a mean of 11.07, and a mode 10.94; while for the Fritz revised intervals the mean is 11.04 and the mode 10.94. The mean deviation of the Wolfer intervals from 11.1 years is ±1.61 for the maxima. For the Fritz intervals, the deviation from 11.0 is ±1.70. The mean variability of the Wolfer intervals is ±2.71; of the Fritz intervals ±2.46.

The normal period length and normal epochs.—In a former paper **(3)**, I called attention to Newcomb's **(6)** method of evaluating the normal epochs and normal length of period. He derived by a least-square solution the normal length of the period from 1610 to 1900 as 11.13 years. A variation of his method is represented by the equation

$$b=\frac{6}{n^3-n}\Big[(n-1)(y_n-y_1)+(n-3)(y_{n-1}-y_2)+\;.\;.\;.\;.\;.\Big]$$

in which $y_1, y_2\;.\;.\;.\;.\;y_n$ are the epochs of maxima, n the number of epochs, and b the normal length of the period.

The computation of the normal values from the combined Fritz and Wolfer epochs is facilitated by averaging the epochs in groups of seven, which gives a series of 21 mean epochs beginning with 332 and ending with 1882. Denoting the differences between the y's as c's and the coefficients as w's, the work is further shortened by employing $c-77w$ instead of c. The formula then becomes $7b=77+\frac{6\Sigma\,[w(c-77w)]}{n^3-n}$. Computing, $b=11.067$. The normal mid-epoch is 1106.13. The residuals of the observed from the normal epochs are given in table 1.

Methods of statistical analysis and application to solar data.—One of my former papers **(2)** contained a discussion of the statistical criteria for the detection of a systematic order of succession in any series of data. Obviously, if the sequence of any given data is indistinguishable from that shown by a series of random numbers, no periodicity can be present. It was there shown that the sequence of the deviations in the length of the sun-spot period from a normal period, instead of being accidental, as Newcomb concluded, is systematic to a marked degree.

Analysis of the intervals from the combined Fritz and Wolfer epochs of maxima, table 1, necessitated the averaging of three drawings from a bowl of the 147 values to determine approximately the normal random distribution of the intervals between peaks or hollows. This distribution differs from that for an infinite number of random values as determined by Besson **(7)**, owing to the small number of different values, 11. The average interval for the random series (drawings) is 3.18, for the natural data 3.48; the modal or most frequent interval is about 2.40 for the random series, but about 3.25 for the natural data. The essentially systematic character of the natural data is well shown by this statistical analysis. Since the unit interval is 11.1 years, the most frequent interval in years is 3.25×11.1, or 36 years.

Where such persistent deviations from a random sequence occurs, it can only be regarded as due to the existence of a definite periodicity of variable length, whose average length should theoretically differ little from the value of the mode above derived, 36 years. The reader is referred to my papers **(4)** and **(5)** for a discussion of variable periods and the methods of investigation employed in the present paper.

THE 37-YEAR PERIOD

It has been shown that in the sequence of the 11-year intervals there is a recurrence of extreme long or short values about every 36 years. With this provisional length of the period we draw the smooth curve through these intervals (fig. 1). While the most frequent interval between these extremes is about 36 years it is seen that there are quite wide deviations from this value in the actual intervals. These deviations are due partly to inaccuracies in the data but mostly to a systematic variation in the length of this interval, which will be discussed below.

The 37-year epochs.—The epochs derived from the smooth curve are given in table 2. There is some uncertainty regarding the epochs since 1850. They are designated as epochs of the 37-year period. The epochs which date the short 11-year intervals are called epochs of maxima, and vice versa. The normal length of the period derived by the least-square method from 300 to 1900 is 37.5 years.

Referring to my 1905 paper **(1)** it will be noted that the 37-year epochs given there agree closely with my recent determinations except in the sixth century, where, owing to the changes made in the Fritz epochs, above noted, one maximum epoch and one minimum epoch have been omitted.

Other solar data showing a 37-year period are the relative numbers at maxima and the ratio a/b, (a, the ascending; b, the descending branch of 11-year curve) as shown in chart 1 of my 1905 paper. *The relative numbers vary inversely with the length of the 11-year period with an average lag of 5 years, while the ratios vary directly with an average lag of 7 years.*

Amplitude of the 37-year period.—The amplitude of the period is derived by averaging the 11-year intervals at the epochs of maxima and minima of the period. For the period from 1610 to 1920 the averages are, long 13.8 years, short 9.2 years; whence the amplitude is 2.3 years. Between 300 and 1600 the 11-year intervals from maxima only are available, and obviously the range derived from the maxima and minima of the curve will be less than the true range. The averages are, long 13.1 years; short, 8.9; whence the amplitude is 2.1 years.

THE 83-YEAR PERIOD

The 83-year variation in the length of the 11-year period.—In order to disclose periods longer than 37 years in the series of 11-year intervals, it is necessary to employ an appropriate smoothing formula. The 11-year intervals smoothed by the formula (a+2b+2c+d)÷6 are plotted in figure 2, curve 1. The epochs of maxima and minima of the curve are given in table 3. The normal length of the period by the least-square method is 83.1 years and the normal mid-epoch is 1132.4.

Amplitude of the 83-year period.—The amplitude of the period can be approximately derived by averaging the

maxima and the minima of the curve and applying the proper factor to correct for the reduction in the range effected by the smoothing formula. The mean amplitude after applying this reduction factor is 1.52 years.

The 83-year variation in the relative numbers and in the ratio a/b.—The relative numbers at spot maxima and the ratios smoothed by running means of seven terms are shown in figure 2. Comparing these curves with curve 1 the following relations for the 83-year variation in various solar data are derived. *The relative numbers vary inversely with the ength of the 11-year period with a lag of about 10 years, while the ratios vary directly with a lag of about 15 years.* These relations are the same as with the 37-year period, but the lag is about twice as great.

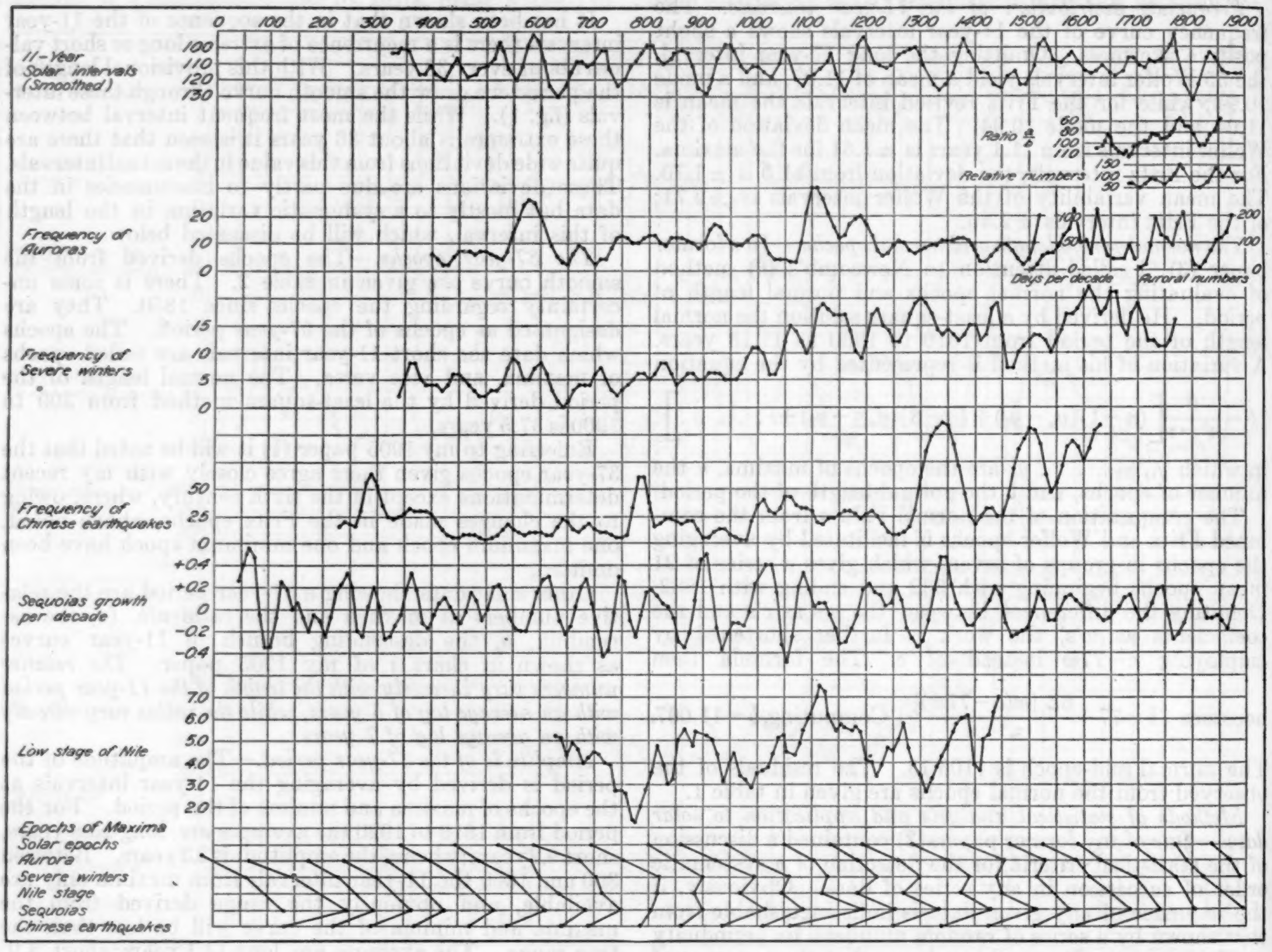


FIGURE 2.—The 83-year period in various solar and terrestrial data. Epochs of maxima are plotted below and joined to show interrelations and lags.

THE 300-YEAR PERIOD

The 300-year variation in the length of the 11-year period.—The averages of the 11-year intervals for each half-century are shown plotted in figure 3, and the epochs of maxima and minima are given in table 4. The average length of the period is about 300 years but varies between 225 years around 400 A.D. and 1650, and 375 years around 1100 A.D. This variation in the length of the period indicates a still longer secular variation which may be roughly estimated as around 1,400 years.

The amplitude of the 300-year variation.—A smoothing of the 11-year intervals by successive summations of 11 terms further smoothed by summations of 7 terms satisfactorily eliminates all periods shorter than 300 years. The amplitude of the period can be approximately derived by averaging the five maxima and five minima of the curve and applying the proper factor to correct for the reduction in the range effected by the smoothing. The result is 0.48 year, or about one-third that of the 83-year period and one fifth that of the 37-year period.

The 300-year variation in the residuals.—The residuals in table 1, averaged by half-century intervals, are plotted in figure 3, and the epochs derived from this curve are given in table 4. The epochs of maximum minus residuals are called epochs of maxima, while the epochs of maximum plus residuals are called epochs of minima.

The 300-year variation in the solar activity and in the ratio a/b.—As stated in my 1905 paper (1) (p. 66), and shown in figure 2 herewith, a minimum of solar activity prevailed about 1680, associated with a maximum value of the ratio a/b. The reverse conditions prevailed around 1780. Thus with the long period as with the shorter periods *the solar activity varies inversely with the length of the 11-year period.*

The 300-year variation in the length of the 37-year period.—The intervals between like phases of the 37-

year epochs in table 2 were smoothed by successive means of three terms. The resulting values are shown

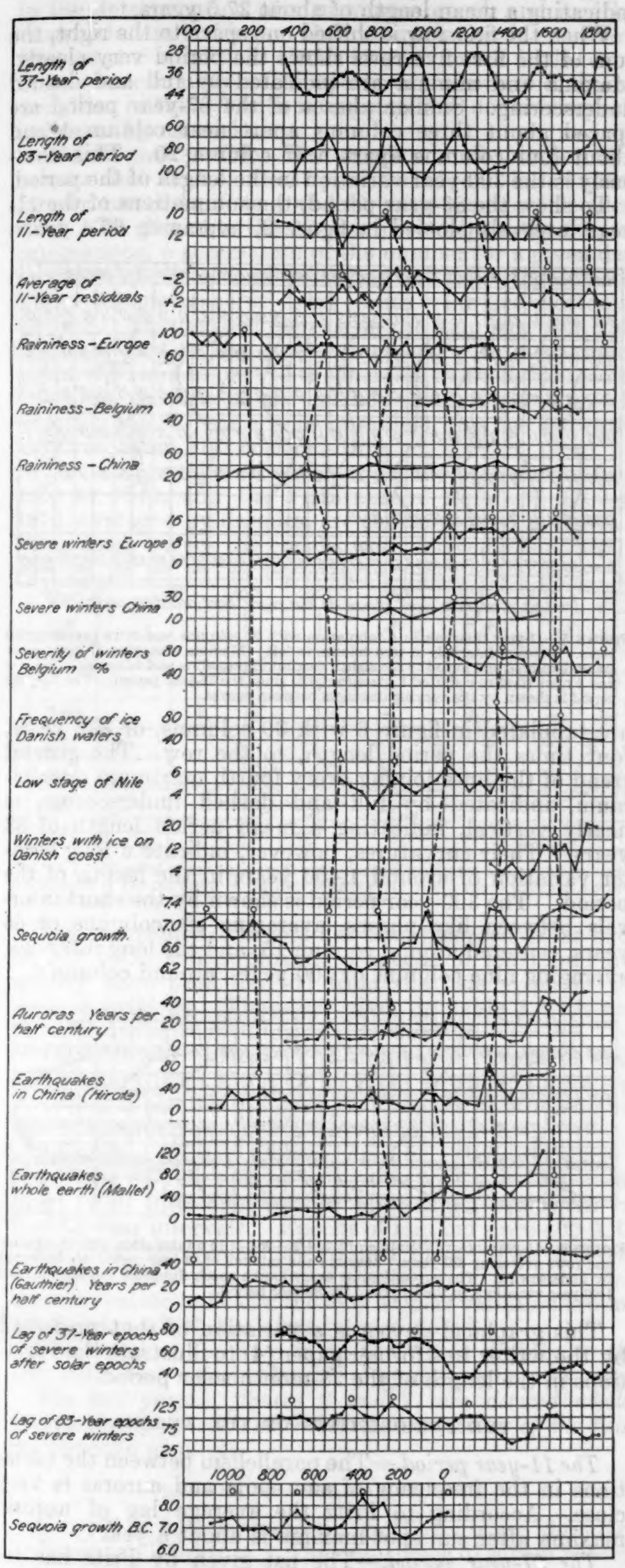


FIGURE 3.—The 300-year period in various solar and terrestrial data. Maxima are indicated by open circles and joined by broken lines.

in figure 3, curve 1. From this curve are derived by simple inspection the epochs of maximum and minimum length of the 37-year period, given in table 4. These epochs show a 300-year variation in the length, which ranges between 27 and 50 years.

The 300-year variation in the amplitude of the 37-year period.—The range of the 37-year period is the difference in years between adjacent peaks and hollows of curve 1, figure 1. These ranges, smoothed by five term averages, show a 300-year period with the epochs given in table 4. Owing to the crudeness of the original data, the agreement between the two series of epochs is not very close, but the averages of the nine epochs in each series agree within 8 years, showing that the length and amplitude of the 37-year period vary directly with each other.

This is an extremely significant and important result and the relation may be expressed in very general terms as follows: *If a series of data shows a systematically varying period, the amplitude varies directly with the length of the period.* This seems to be a law of universal application for all periods which vary in length, both solar and meteorological.

The 300-year variation in the length of the 83-year period.—The intervals between the 83-year epochs of maxima and minima are shown plotted in figure 3, curve 2. These range between 55 and 110 years. The epochs of the 300-year period derived from this curve are given in table 4. These epochs have long intervals, averaging 330 years, around 1250 and short intervals, 290 years, in the early and latter part of the series, indicating a long secular variation in the length of the 300-year period.

It will be seen that curves 1 and 2 have nearly reversed phases. The persistence of this feature for 1,500 years is highly significant and is strong evidence for the reality of the two periods.

PERIODICITY TABULATIONS

Tabulation of the 11-year epochs.—If the positions of the 11-year epochs of maxima or minima are plotted in a table with rows 11 years apart and the epochs joined, forming a zigzag line as in figure 4, the variations in the period length are graphically indicated. Every fifth row gives the date of the zero column. The zigzag line is essentially a plot of the accumulated sums of the departures of the 11-year intervals from 11 years. It is also a plot of the residuals, table 1, the zero line being the straight line of best fit, shown as a heavy full line.

The most conspicuous variation is the 300-year period shown by the dotted curve. The integration or successive summation of departures exaggerates the amplitudes of the long periods. The long interval around 375 years midway in the curve and the short intervals around 225 years in the early and latter portions are clearly evident. Upon the long variation are superposed the shorter 83-year and 37-year variations. The latter are indicated approximately by circles at the right, and the former by circles at the left. The opposite phases are midway between the phases thus indicated. Theoretically the phases of a mass curve are advanced one fourth the wave length and in this case the epochs of the residuals, table 4, are shifted about 75 years from the epochs of the length of the period.

Tabulation of the 11-year intervals.—These tabulations contain more than one maximum or minimum phase of a period to the row. To show the 37-year period, the intervals are tabulated as in figure 5 in rows of 27 intervals each, or approximately 300 years to the row, and the maxima averaging 37 years apart are underscored. Each maximum is joined to the eighth maximum, preceding and following. The date of the beginning of the interval in the zero column is at the left. Since the mean length of the rows is 300 years, or nearly four times the 83-year

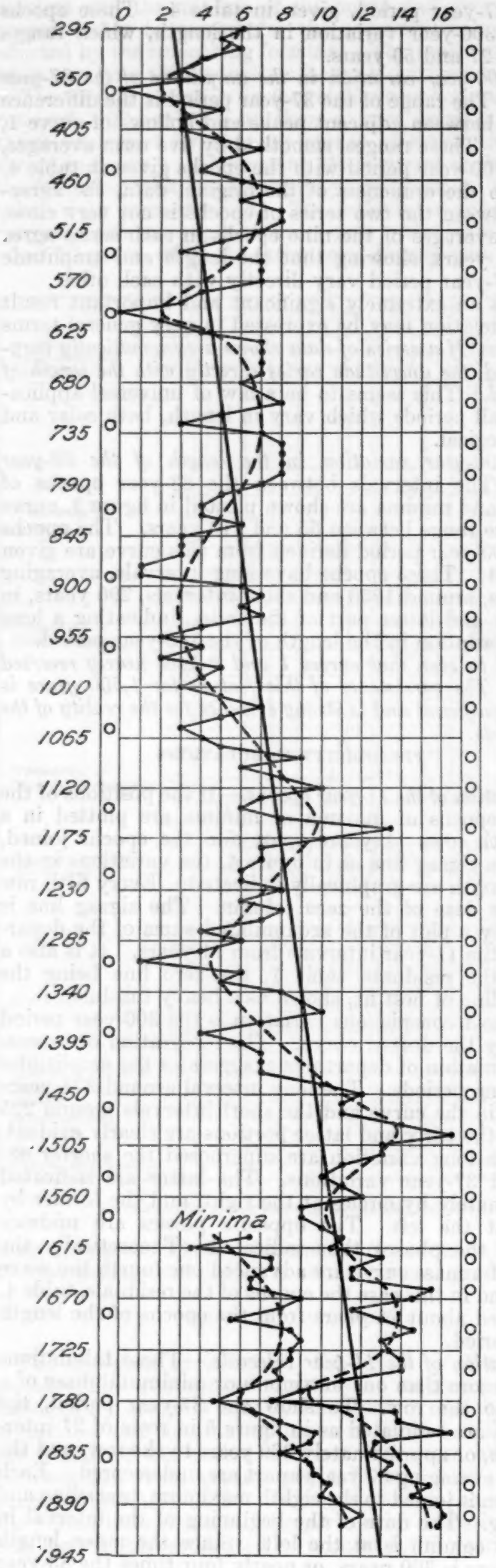


FIGURE 4.—Epochs of sun-spot maxima. Date of zero column for every fifth row at left. The dots representing the epochs are joined by full lines. The broken curved line shows the 300-year period. The straight line is the line of best fit to the plotted data. Open circles at the right and left indicate extreme variations due to the 37-year and 83-year periods, respectively. Wolfer epochs of minima are plotted at left.

period, these two periods are practically eliminated and the general trend of the connecting lines is nearly vertical, indicating a mean length of about 37.5 years.

When the first row is shifted one space to the right, the sum of the first five rows shows the period very clearly. Maxima and minima are indicated by full and dashed underscoring. Similar phases of the 37-year period are spaced about three columns apart near column 4 and about four columns apart near column 20. This obviously is the 300-year variation in the length of the period.

To show the 83-year period, the summations of the 11-year intervals plotted in figure 2, averaging 66.4 years,

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	0	1
301	10	12	9	10	12	7	13	14	9	11	13	13	9	10	13	13	9	13	11	10	9	9	15	11	11	8	10	8	13
595	8	13	13	14	11	11	11	10	12	12	8	9	15	12	11	11	11	10	9	10	11	13	8	11	11	9	11	16	12
890	16	12	10	12	8	9	13	9	14	10	10	13	13	9	9	12	12	15	8	13	13	8	10	13	16	8	8	11	10
1193	11	10	11	13	9	13	10	8	13	9	8	16	10	14	12	12	8	8	13	12	11	11	14	13	10	11	14	14	7
1497	14	7	11	9	10	12	12	8	11	12	12	10	14	10	11	15	10	8	12	13	9	11	12	11	8	9	10	17	11
1788	17	11	14	7	11	12	10	15	10	12	11	11																	
* Sums	58	52	57	57	48	57	53	48	64	52	49	61	65	54	53	63	54	50	55	59	54	52	53	63	56	48	51	68	48

* Shifting first row one space to the right and omitting sixth row

FIGURE 5.—11-year intervals in a tabulation with 27 columns and rows averaging 300 years. Dates of intervals in zero column at left. Maxima averaging 37 years apart are underscored and joined to the eighth maximum preceding and following. Sums of first 5 rows (first row shifted 1 space to right) show the 37-year period. The 300-year period is shown by the varying distances between curves.

are tabulated in figure 6 with 30 columns, or 332 years, four times the period length, to the row. The general trend of the lines joining every fourth maximum or minimum, indicated by full and dashed underscoring, is nearly vertical, indicating a mean period length of 83 years. Their curvatures, however, indicate a long secular variation of around 1,400 years in the length of the period. The 300-year period is shown by the short intervals between like phases, averaging six columns or 66 years, centered around column 15, and the long intervals, averaging nine columns or 100 years, around column 0.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	0	1	2
323	62	62	60	61	66	70	70	67	70	72	67	64	68	71	70	68	67	64	58	61	68	72	67	59	55	57	65	74	78	74	69	65	65
654	69	65	65	67	66	61	61	68	74	72	67	65	62	59	59	64	66	64	62	61	62	67	75	77	72	64	59	59	61	67	69	67	67
979	69	67	67	69	71	66	61	63	72	74	71	70	68	65	62	70	76	69	59	56	61	66	67	68	67	63	62	61	60	63	67	74	76
1308	67	74	76	74	70	60	57	62	69	70	70	74	75	71	69	74	74	67	59	57	61	65	66	63	62	66	69	70	69	68	70	71	69
1649	70	71	69	64	64	67	68	65	66	65	59	55	62	74	80	74	64	62	64	69	70	70	70	68									

FIGURE 6.—11-year intervals summed by $(a+2b+2c+d)$ in a tabulation with 30 columns and rows averaging 332 years. Maxima and minima of 83-year period are indicated by underscoring. The curves joining every fourth epoch illustrate the 300-year and 1400-year variations in the length of the 83-year period.

This graphical device is a variation of that presented by the writer in a former paper (4) to illustrate the variations in the length of the 28-month solar period.

THE PERIODICITIES OF THE AURORA

The 11-year period.—The parallelism between the variations in the frequency of sun spots and auroras is very close. According to Fritz the average lag of auroral maxima after sun spot maxima is about a year.

The 37-year period.—The list given by Fritz has received some additions derived from the Lovering and Short catalogs. The total number of auroras in the 20-year interval centered on every fifth year is plotted in

figure 1. Most of the maxima are obvious, but in some cases the unsmoothed or original data must be considered in the determination of a maximum epoch and in other cases data are lacking so that interpolation is necessary. The greater amplitude of the 83-year period is the cause of some uncertainty. The epochs of maxima and minima are given in table 2 with interpolated or doubtful epochs indicated by asterisks.

The 83-year period.—The amplitude of this period is greater than that of the 37-year period, and it can therefore be traced back to 400 A.D. with considerable accuracy. To eliminate the 37-year period from the 20-year summations, a summation of the number for a given date and that of the second preceding and following is made. These summations for every tenth year are plotted in figure 2. The marked increase in the numbers from 1525 is due in part to the secular variation with a maximum about 1550 and in part to the increase in available records following the era of the introduction of printing. In selecting the 83-year epochs in table 3, this secular variation was taken into consideration.

The total number of days per decade with aurora from 1500 to 1740, and the Fritz auroral numbers, 1700 to 1870, averaged by decades, are shown plotted in figure 2. From these curves the epochs were derived after 1600.

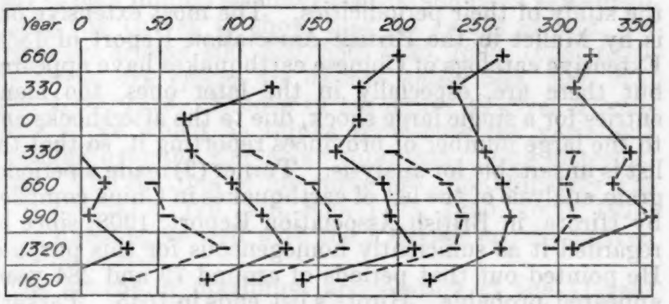


FIGURE 7.—Plus-and-minus signs are 83-year epochs of maximum and minimum auroral frequency. The curvature of the lines joining every fourth epoch indicates a secular variation of around 1400 years in the length of the period.

The occurrence of aurora has been recorded as far back as 503 B.C., and approximate epochs of maximum frequency have been derived from the lists given in the various catalogs. These are given in table 3 with two interpolated epochs indicated by asterisks.

The 300-year period.—The number of years in each half-century from 350 A.D. to 1750, in which aurora was recorded, is plotted in figure 3. The epochs of maximum and minimum frequency are given in table 4.

Tabulation of the 83-year auroral epochs.—Figure 7 shows the 83-year epochs in a table with rows 330 years long. Full lines join epochs of maxima separated by four 83-year intervals. Epochs of minima since 400 A.D. are plotted and joined by dashed lines. The 300-year variation is eliminated from the trend of the lines and their curvature indicates the long secular variation around 1,400 years which has already been noted.

The trend of the lines is on the whole slightly to the left, indicating a period length of approximately 82 years.

The two graphs, figures 6 and 7, are derived wholly independently of each other but the curvatures of the lines are virtually identical.

SEVERE WINTERS IN EUROPE

Records of unusual meteorological events are abundant in European literature. The occurrence of severe winters has been very consistently recorded, and Brückner, by means of this material, was enabled to extend his 35-year cycle, deduced from modern instrumental records, back to the year 1000. The reader is referred to my 1905 paper (1) for a discussion of his results together with additional results derived from my own researches. Brückner used Pilgram's catalog and began with the year 800 but he regarded the records previous to 1000 as of little value.

To extend the series backward, I have used Hennig's catalog which is very complete. Easton's list was also consulted. Employing the method used by Brückner, the total number of severe winters in the 20-year interval centered on every fifth year were counted and the numbers from 340 to 1030 together with his numbers from 1030 to 1775 are shown graphically in figure 1.

The 37-year period.—Maxima and minima are quite definitely apparent except in a few instances where data are lacking. The maximum and minimum epochs are given in table 2 with interpolated epochs indicated by asterisks.

The 83-year period.—In order to eliminate the 37-year period a smoothing process similar to that used on the auroral numbers was employed, and the smoothed values for every tenth year plotted in figure 2. The derived epochs of maxima and minima are given in table 3. Epochs previous to 300 A.D. are only approximate.

The 300-year period.—In Brooks' "Evolution of Climate" the number of severe winters in Europe per half-century are given from 800 A.D. and I have extended the data back to 300 A.D. from Hennig's catalog. These numbers are shown in figure 3.

FLOOD AND LOW STAGES OF THE NILE

A remarkable series of yearly records of high and low levels of the Nile at the Roda gage, Cairo, from 622 A.D. to 1470 has been published by Prince Omar Toussoun. The original records are in cubits and dated in Mohammedan years. One list from 640 to 1451 was published in 1923. Another list from 622 to 1470 in metric equivalents and corrected to the modern calender was published in 1925. These two lists differ slightly and after careful examination of the graphs of both lists it was decided to use the first one, making a few corrections to readings, evidently misprints, by comparison with the later list and supplying a number of missing years. Five-year means have been computed for both flood and low stages.

The 11-year period.—The influence of the 11-year solar period on the flood stages is shown by an excessive predominance in the 5-year means of the two-interval over the normal frequency for random numbers, 50 percent vs. 40 percent. As for the minima there is a relative excess of the four- and five-intervals, indicating a 20- to 25-year period.

The 37-year period.—When the pentad means of the flood stages are smoothed by the formula, $(a+b)\div 2$, the 11-year period is eliminated and the longer periods can be recognized. The smoothed means are shown in figure 1. Epochs of the 37-year maxima and minima corrected to the Gregorian calender are given in table 2.

The 83-year period.—The contrast between the flood and low stages, both in their origin and in the short periods shown by the pentad means, is further shown by the longer periods. The 37-year period is best shown by the flood levels while the longer periods are best

shown by the low stages. Figure 2 shows 10-year means of the low stages smoothed by $(a+b)\div 2$.

The 37-year period somewhat obscures the longer period in the curve of flood stages, but the epochs of the longer period are nearly coincident in the two curves. Averages of the two series of epochs are given in table 3.

Brooks (8) made a periodogram analysis of the Nile flood data using the same list as that published in 1923, and found that a period of about 77 years is the only period that could be regarded as real, judging from the mathematical criterion.

The 300-year period.—Fifty-year means of the low stages of the Nile are shown plotted in figure 3. The 300-year variation is clearly evident. This long period can be seen also in the curve of flood stages and the maxima and minima of the two curves are virtually identical. The secular increase in the levels of both high and low stages is due to the raising of the Nile bed by the deposition of the silt which it brings down.

WHEAT PRICES IN ENGLAND

In a paper published after his "Klimaschwankungen", Brückner concluded from an examination of wheat prices in western Europe for 200 years that high prices occur during or shortly after periods of maximum rainfall. Beveridge (11) computed yearly index numbers of wheat prices in England from 1500 to 1870 by expressing them as a percentage of 35-year moving averages. His periodogram of wheat prices shows a period of considerable amplitude at 35.5 years.

I have taken Rogers' wheat prices in England from 1265 to 1700 and formed index numbers by expressing the 5-year means as a percentage of moving averages of 7 pentad means. From 1700 to 1870 5-year means of Beveridge's index numbers are employed. After 1870, the Sauerbeck index numbers are used. These pentad index numbers, smoothed by the formula $(2a+3b+2c)\div 7$, are shown graphically in figure 1. Table 2 gives the epochs of maxima and minima. These epochs are virtually identical with the epochs of wheat prices in my 1905 paper.

TREE GROWTH IN ARIZONA AND CALIFORNIA

Douglass was an early investigator of tree-growth in its relation to climate. Some of his early measurements were published in MONTHLY WEATHER REVIEW, June 1909. Huntington published in 1912 results of his measurements of the tree rings of the California Sequoias.

The 37-year period.—In his "Climatic Cycles and Tree-Growth," volume 1, Douglass gives a table of mean yearly growth of 5 yellow-pine trees measured near Flagstaff, Ariz., dated from 1503 to 1910 and of 2 trees from 1385 to 1503. This record appears to be quite homogeneous. Residuals of 5-year means of these measures from a smooth curve, formed by successive means of 8 values further smoothed by means of 2 terms, were smoothed by the formula $(a+2b+3c+2d+e)\div 9$ and the final values plotted in figure 1. The 37-year epochs derived from inspection of this curve are given in table 2. Other records from trees in New Mexico, Colorado, and Utah show this variation with epochs nearly synchronous with those of the Flagstaff region.

The 83-year period.—We are indebted to Huntington for an extensive series of measurements of the growth rate of the California Sequoias. His material has been worked over by Antevs (12) who divided it into two groups—"A", trees growing in dry situations; and "B", trees growing in moist situations. His tables give the total growth for each decade from 1000 B.C.

The trees in moist situations seem to respond to changes in meteorological conditions affecting their growth sooner than those in dry situations, and their variations are somewhat more regular. For these reasons the "B" series of means are selected to show the 83-year period. The secular trend in these values has been eliminated by taking residuals from successive means of nine terms. These residuals smoothed by $(a+2b+c)\div 4$ are plotted in figure 2. The 83-year epochs selected from the original and smoothed curves are given in table 3. The epochs derived from the growth rate of trees in dry situations lag about 10 years after these epochs.

For the years previous to the Christian era, the data from trees in both dry and moist situations (Antevs' "C" group) were used, since the total number is small. The 83-year epochs are given in table 3.

The 300-year period.—To show this period, 50-year means of Huntington's Sequoia measurements are plotted in figure 3. The maximum at 800 is weak but is well marked in Antevs' curve "B".

CHINESE EARTHQUAKES

A number of catalogs of earthquakes are available for the study of their periodicities. The most extensive one is by Mallet in the British Association Report of 1858. Extensive catalogs of Chinese earthquakes have appeared but there are, especially in the later ones, too many entries for a single large shock, due to the aftershocks and to the large number of provinces reporting it, so that the list is unsuitable for analysis. Turner (9) made a periodogram analysis of the list of earthquakes in China compiled by Hirota, in British Association Report, 1908, since he regarded it as sufficiently homogeneous for this purpose. He pointed out that periods of around 79 and 284 years appeared probable. Hirota's list ends in 1645. Parker's list in British Association Report, 1909, extends from 1640 to 1875, but it lists only the greater shocks. It is, however, internally homogeneous and shows the 37-year period fairly well.

The 37-year period.—I have counted the number of shocks in these two lists for each 20-year period, as in the case of severe winters, and the number for each fifth year is plotted in figure 1. Between A.D. 195 and 225 there are no records owing to the Great Rebellion. Epochs of maxima are given in table 2.

The 83-year period.—Smoothing the earthquake numbers in the same manner as those of severe winters, the 37-year period is eliminated. These numbers by decades plotted in figure 2, show the 83-year period with epochs as given in table 3. Two epochs of maxima are interpolated. One at 220 occurred during the civil war and the other at 1250 is not obvious from the data which seem to be unusually scanty at this time. However, there is a pronounced maximum of Japanese earthquakes near this date. The maximum at 1630 is unreliable owing to the ending of the record around 1640 and evidence from other lists points to 1650 as a more probable date. The 83-year epochs after 1650 cannot be reliably determined.

The 300-year period.—The number of Chinese earthquakes per half-century from Hirota's list, and also the numbers derived from Mallet's list, are plotted in figure 3. Previous to 400 A.D., Mallet's data are too scanty to show the secular variation. The number of years per half-century with earthquakes in China, compiled from the list by Gauthier in Bull. de l'Observ. de Zikawei, 1907, is also plotted. This curve shows clearly the 300-year

variation and the other two curves are in fair agreement. The numbers in the first half of the third century were doubled owing to the hiatus in the records.

THE 300-YEAR PERIOD

The 300-year period has already been shown to exist in the variations of solar and certain terrestrial data. Other data from literary records have been brought together by Brooks and the variations in these data seem to fit in well with those of auroras, etc. In his "Climate through the Ages", table 22, under Europe (general) and Belgium, the percentage of a to $a+b$ is an index of the raininess of these regions. Similar indexes for the severity of winters in Belgium were computed by me from Vanderlinden's catalog. From Speerschneider's compilation the percentage of years with heavy ice in Danish waters and the number of winters with ice on the Danish coast were obtained. From Co Ching Chu (**10**) are derived indexes of the raininess and the number of severe winters in China since the first century A.D. These data are shown graphically in figure 3. To facilitate intercomparison of the variations in these curves, the 300-year maxima are indicated by circles and these are joined by broken lines.

While the data graphically shown in figure 3 are obviously of only limited accuracy there is sufficient agreement among the curves to show that *the epochs of cold, wet periods are around 200, 550, 850, 1125, 1350, 1625, 1850. The warm, dry epochs are approximately 350, 700, 975, 1250, 1500, 1725.* Brooks in his figure 38 gives a composite curve which he thinks represents the variations of rainfall over the Eur-Asian continent during historical times. The maxima of his curve are approximately 425 B.C., 125 B.C., 175, 525, 850, 1125, 1350, 1600, 1825. These dates agree well with the 300-year epochs derived from the curves.

The epochs of maximum acceleration of the 11-year epochs, derived from curve 4 and given in table 4, precede, 50 to 225 years, the epochs of maxima of rainfall. The lag is variable, being greatest around 800 and least around 1600.

THE 1400-YEAR PERIOD

A long period of approximately 1,400 years was noted above in the variations in the length of the 11-, 37-, 83-, and 300-year solar periods. The 83-year period in the aurora also gives clear evidence of this long period. Since the frequency of auroras correlates closely with that of severe winters in the shorter 37- and 83-year periods, there should be evidences of the long period in meteorological fluctuations. Brooks (*loc. cit.*) has brought together all available evidence relating to climatic fluctuations during the last 5,000 years. His results should furnish impartial evidence as to the existence of the long period, and a summary follows of the maxima and minima in his climatic curves which seem to recur at intervals averaging 1,400 years. His curves showing variations of rainfall in Europe and Asia indicate well-defined minima around 2200 B.C., 1000 B.C., and 600 A.D. Maxima are shown near 3000 B.C., 1300 B.C., between 800 B.C. and 350 B.C., and near 1300 A.D. The maximum in the first millenium B.C. is the so-called "Classical" rainfall maximum, and the maximum near 1300 is the "Medieval" rainfall maximum. According to Peake, as quoted by Brooks, a period of drought occurring some centuries before 3000 B.C. caused migrations from the interior toward the Baltic, while the great dispersal occurred about 2200 B.C. Brooks places the post-glacial "Climatic Optimum" at this time. Huntington's curve of tree-growth has chief maxima at 400 B.C. and 1300 A.D. and a minimum at 700 A.D. Brooks' curve of temperature in Europe shows a maximum about 700 A.D. and minima 0 to 250 B.C. and around 1500 A.D. The deterioration of climate in Greenland from about 900 A.D. to 1400 is consistent with these fluctuations in Eur-Asia and North America.

It is clear, therefore, that *marked climatic extremes have occurred in the Northern Hemisphere with intervals averaging 1,400 years.*

CORRELATION BETWEEN SOLAR AND TERRESTRIAL VARIATIONS

In figures 1 and 2, below the curves, the 37-year and 83-year epochs of minimum length of the 11-year solar period are plotted on their respective dates. Next below are the corresponding epochs of maximum frequency of the aurora. Then follow the epoch of maxima for severe winters, Nile levels, wheat prices, tree growth, and Chinese earthquakes. Connecting lines are drawn to show the relations and the varying lags. In general the lags are greater before 1000 A.D. than afterwards.

The 37-year period.—The lag of the auroral after the solar epochs averages 24 years—33 years before 1000 and 15 years after. The lag of the epochs of severe winters averages 56 years—70 before 1000 and 44 after. With reference to the epochs of severe winters, the lag of the Nile flood epochs is 1.5 years; that of wheat prices 5 years; that of Arizona pines 23 years. The relation of earthquakes to other terrestrial events is uncertain, but assuming that indicated by the lines, the maxima average 13 years earlier than those of severe winters.

The 83-year period.—The lag of the auroral after the solar epochs is 55 years; that of severe winters averages 91 years—107 before 1000, and 79 thereafter. The lag of the Nile stage after severe winters is 8 years, Sequoia growth 63 years. Chinese earthquakes precede severe winters by about 13 years. *It will be seen that the lags vary directly with the length of the period* and that in the case of severe winters the lag after 1000 is about two thirds that previously. A similar lag was noted above for the 300-year epochs of rainfall. This long-period variation in the lag is probably due to the 1,400-year period.

The 300-year variation in the lag.—There is a well-defined 300-year periodicity in the lag of the epochs of severe winters after the solar epochs in both 37-year and 83-year periods (cf. fig. 3). For the 37-year period, the maximum lag occurs around 360, 715, 975, 1335, 1700; minimum lag 580, 900, 1200, 1540, 1810. These epochs of maximum and minimum lag average 100 years after the epochs of short and long 37-year intervals in table 4. For the 83-year period, the maximum lag occurs around 400, 675, 860, 1235, 1610; minimum lag 525, 780, 1050, 1380, 1775; or about 90 years after the epochs of short and long 83-year intervals in table 4.

These consistent variations in the lags of the meteorological events and their persistency for 1,500 years afford additional proof of the reality of both the solar and meteorological periods.

LITERATURE CITED

(**1**) Clough, H. W. 1905. Synchronous variations in solar and terrestrial phenomena. Astrophy. Jour., 22: 42–75.

(**2**) Clough, H. W. 1921. A statistical comparison of meteorological data with data of random occurrence. Mo. Wea. Rev., 49: 124–132.

(**3**) Clough, H. W. 1923. An improved method of computing meteorological normals. Mo. Wea. Rev., 51: 391–395.

(**4**) Clough, H. W. 1924. A systematically varying period with an average length of 28 months in weather and solar phenoma. Mo. Wea. Rev., 52: 421–441.

(5) Clough, H. W. 1928. The 28-month period in solar activity and corresponding periods in magnetic and meteorological data. Mo. Wea. Rev., 56: 251–264.

(6) Newcomb, Simon. 1901. The period of the solar spots. Astroph. Jour., 13: 1.

(7) Besson, Louis. 1920. On the comparison of meteorological data with results of chance. Mo. Wea. Rev., 48: 89–94.

(8) Brooks, C. E. P. 1928. Periodicities in the Nile floods. Mem. Roy. Met. Soc., Vol. II, No. 12.

(9) Turner, H. H. 1925. Note on the 284-year Period in Chinese Earthquakes, Mon. Not. Roy. Astr. Soc., Geoph. Suppl., vol. I, no. 6.

(10) Chu, Co Ching. 1926. Climate pulsations during historic time in China. Geogr. Rev. 16: 274.

(11) Beveridge, W. H. 1922. Wheat prices and rainfall in western Europe. Jour. Roy. Stat. Soc., vol. 85, part 3, 412.

(12) Antevs, Ernst. 1925. The big tree as a climatic factor. Quart. climates, Carnegie Inst. Pub. 352: 115.

Table 1.—*Epochs of sun-spot maxima (Fritz and Wolfer)*

1. Epochs of sun-spot maxima.
2. 11-year intervals.
3. Residuals from normal epochs.

* Interpolated epochs.

1	2	3	1	2	3	1	2	3
301.5		+3.5	848.5	8	−3.0	1388.5	8	−5.5
311.5	10	+2.4	859.5	11	−3.1	1401.5	13	−3.5
323.5	12	+3.3	870.5	11	−3.2	1413.5*	12	−2.6
332.5*	9	+1.3	879.5	9	−5.2	1424.5*	11	−2.7
342.5	10	+0.2	890.5	11	−5.3	1435.5	11	−2.7
354.5	12	+1.1	906.5	16	−0.4	1449.5*	14	+0.2
361.5	7	−2.9	918.5	12	+0.6	1462.5	13	+2.1
374.5	13	−1.0	928.5	10	−0.5	1472.5	10	+1.1
388.5	14	+1.9	940.5	12	+0.4	1483.5	11	+1.0
397.5	9	−0.1	948.5*	8	−2.7	1497.5	14	+3.9
408.5	11	−0.2	957.5	9	−4.7	1511.5	14	+6.9
421.5	13	+1.7	970.5	14	−2.8	1518.5	7	+2.8
434.5	13	+3.6	979.5	9	−4.9	1529.5	11	+2.7
443.5*	9	+1.6	993.5	14	−1.9	1538.5	9	+0.6
453.5	10	+0.5	1003.5	10	−3.0	1548.5	10	−0.4
466.5*	13	+2.4	1013.5	10	−4.1	1560.5	12	+0.5
479.5	13	+4.4	1026.5*	13	−2.1	1572.5	12	+1.4
488.5	9	+2.3	1039.5	13	−0.2	1580.5	8	−1.6
501.5	13	+4.2	1048.5*	9	−2.3	1591.5	11	−1.7
512.5	11	+4.1	1057.5	9	−4.3	1603.5	12	−0.8
522.5*	10	+3.1	1069.5	12	−3.4	1615.5	12	+0.1
531.5*	9	+1.0	1081.5	12	−2.5	1626.0	10	−0.4
540.5	9	−1.1	1096.5	15	+1.4	1639.5	14	+2.0
555.5	15	+2.9	1104.5	8	−1.6	1649.0	10	+0.4
566.5	11	+2.8	1117.5	13	+0.3	1660.0	11	+0.4
577.5	11	+2.7	1130.5	13	+2.2	1675.0	15	+4.3
585.5	8	−0.3	1138.5	8	−0.8	1685.0	10	+3.2
595.5	10	−1.4	1148.5	10	−1.9	1693.0	8	+0.2
603.5	8	−4.5	1161.5	13	0.0	1705.5	12	+1.6
616.5	13	−2.5	1177.5	16	+4.9	1718.2	13	+3.2
629.5	13	−0.6	1185.5	8	+1.9	1727.5	9	+1.5
643.5*	14	+2.3	1193.5	8	−1.2	1738.7	11	+1.6
654.5	11	+2.2	1204.5	11	−1.3	1750.5	12	+2.1
665.5*	11	+2.2	1214.5*	10	−2.3	1761.5	11	+2.2
676.5	11	+2.1	1225.5	11	−2.4	1769.7	8	−0.6
686.5*	10	+1.0	1238.5	13	−0.5	1778.4	9	−3.0
698.5*	12	+2.0	1242.5	9	−2.5	1788.1	10	−4.4
710.5	12	+2.9	1260.5	13	−3.6	1805.2	17	+1.7
718.5*	8	−0.2	1270.5*	10	−1.7	1816.4	11	+1.8
727.5	9	−2.3	1278.5	8	−4.7	1829.9	14	+4.2
742.5	15	+1.7	1291.5	13	−2.8	1837.2	7	+0.4
754.5	12	+2.6	1300.5*	9	−4.9	1848.1	11	+0.3
765.5	11	+2.5	1308.5	8	−8.0	1860.1	12	+1.2
776.5	11	+2.5	1324.5	16	−3.0	1870.6	11	+0.6
787.5	11	+2.4	1334.5	10	−4.1	1883.9	13	+2.8
797.5*	10	+1.3	1348.5	14	−1.2	1894.1	11	+2.0
806.5	9	−0.7	1360.5	12	−0.2	1906.4	12	+3.2
816.5*	10	−1.8	1372.5	12	+0.7	1917.6	11	+3.3
827.5	11	−1.9	1380.5	8	−2.4	1928.4	11	+3.1
840.5	13	+0.1						

Table 4.—*300-year epochs*

11-year intervals				32-year intervals				83-year intervals		Frequency of auroras		Frequency of rainfall	
Length		Residuals		Length		Amplitude		Length					
Short	Long	Minus	Plus	Short	Long	Min.	Max.	Short	Long	Max.	Min.	Max.	Min.
											400	200	350
	435	360	500	340	500		430		400		700	550	700
550	680	600	750	640	780	670	890	540	700	575	1025	850	975
825	1050	925	1175	950	1060	975	1130	845	900	875	1260	1125	1250
1235	1415	1300	1510	1240	1400	1220	1315	1160	1320	1140	1450	1350	1500
1530	1640	1585	1700	1540	1740	1530	1755	1510	1640	1350	1675	1625	1725
1765		1785		1825				1790		1600		1850	
										1800			

Table 2.—*37-year epochs*

Solar activity		Frequency of auroras		Frequency of severe winters		Nile flood		Arizona pine growth		Wheat prices		Chinese earthquakes
Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
				220								
				250								240
				290								290
				330	350							325
	318			370	390							355
330	348		380	405	420							390
360	380	400	415	440	455							435
398	420	450	465	470	490							470
440	462	480	495	515	530							505
485	505	505	525	555	575							540
530	550	560	575	595	610							570
572	590	590	610	625	640	633	652					600
605	628	625	645	665	685	663	691					645
645	662	675	690	710	730	718	735					685
680	700	720	730	755	775	747	765					735
718	738	750	760	795	810	781	796					785
760	780	800	820	830	845	817	835					815
802	825	840	860	870	885	873	903					840
842	862	870	895	915	930	922	946					880
880	900	920	930	945	960	956	976					930
918	932	945	960	985	1000	990	1007					955
945	962	975	990	1015	1030	1017	1034					1005
975	990	1000	1020	1050	1060	1045	1066					1040
1008	1028	1040	1055	1075	1090	1082	1095					1065
1050	1078	1075	1085	1120	1135	1123	1140					1095
1100	1120	1110	1145	1150	1170	1155	1174					1130
1140	1162	1155*	1170*	1180	1195	1191	1205					1165
1180	1200	1190	1210	1215	1240	1225	1242					1215
1212	1228	1225	1235	1250	1260	1255	1268					1245
1242	1255	1260	1275*	1280	1300	1279	1295			1280	1302	1280
1270	1285	1290*	1300*	1310	1340	1317	1327			1320	1340	1310
1300	1318	1315	1335	1355	1375	1358	1370			1368	1385	1340
1335	1355	1350	1365	1395	1415	1385	1397	1410	1430	1402	1422	1395
1380	1402	1390	1415	1435	1460	1436	1448	1465	1487	1438	1460	1430
1425	1448	1450	1475	1485	1500			1497	1515	1482	1505	1460
1470	1490	1490	1510	1515	1530			1527	1540	1525	1540	1500
1510	1525	1525*	1540*	1545	1555			1560	1582	1552	1568	1550
1540	1560	1555	1570	1580	1590			1615	1632	1595	1610	1580
1575	1595	1585	1605	1615	1635			1647	1667	1628	1640	1625
1615	1630	1625	1655	1655	1675			1680	1682	1660	1682	1660
1650	1668	1665	1695	1695	1715			1717	1740	1698	1725	1700
1690	1705	1708	1715	1730	1755			1762	1780	1738	1752	1755
1725	1748	1740	1765	1775	1790			1793	1810	1770	1782	1790
1770	1792	1788	1810	1815	1825			1830	1847	1812	1828	1820
1808	1822	1830	1835	1840	1860			1865	1882	1852	1862	
1835	1852	1850	1860	1875	1890			1910		1873	1895	
1867	1885	1872		1910	1932					1918		
1905												

* Interpolated epochs.

Table 3.—*83-year epochs*

Solar activity		Frequency of auroras		Frequency of severe winters		Nile stage		Sequoia growth		Frequency Chinese earthquakes	
Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
									1075		
								1040	1000		
								965	945		
								905	875		
								835	785		
								745	710		
								650	605		
								575	535		
								475	440		
								400	345		
		460		400				325	305		
		395		330*				260	195		
		340		270				160	120		
		210		200				85	BC60		
		155		80				BC15	AD15		
		95		BC20*				AD70	100		
		BC20		AD60				130	190		
		AD65		140*				245	275	130	190
		175		230				295	320	220*	260
		240*		300	330			365	390	290	330
		320*		365	415			425	470	370	440
345	395	400	435	450	495			515	560	470	500
445	480	490	525	550	575			610	650	540	595
525	555	585	640	600	640	636	681	685	720	640	665
590	635	675	705	705	745	714	769	750	775	690	750
695	745	755	805	820	850	815	839	805	855	785	810
800	830	850	890	900	950	886	943	900	945	860	905
860	900	925	965	995	1025	970	1002	1015	1055	935	980
945	1000	995	1045	1060	1090	1043	1067	1085	1160	1010	1030
1050	1090	1105	1150	1130	1185	1121	1152	1195	1235	1060	1110
1135	1160	1185	1230	1220	1255	1186	1225	1255	1290	1170	1190
1195	1235	1260	1295	1300	1340	1269	1308	1335	1390	1250*	1260*
1285	1335	1350	1410	1390	1410	1375	1400	1440	1475	1340	1395
1380	1430	1455	1485	1440	1465	1450		1515	1540	1425	1450
1465	1495	1530	1555	1515	1550			1575	1630	1500	1540
1525	1555	1585	1615	1610	1635			1685	1705	1580	1600
1590	1640	1630	1680	1695	1745			1740	1775	1650	
1690	1725	1730	1760	1770	1795			1805	1845		
1770	1800	1790	1815	1820	1860			1885			
1835	1880	1865		1890							
1920											

* Interpolated epochs.

PERSISTENT WEATHER ABNORMALITY

By CHARLES D. REED

[Weather Bureau, Des Moines, Iowa, December 1931]

Certain marked weather abnormalities are known to be persistent. Where great abnormality continues for approximately 30 days and roughly coincides with arbitrary calendar divisions, it is easy to predict that the average temperature of some succeeding months will be above or below normal. No doubt, if sufficient labor were bestowed upon the problem, breaking the time division into other lengths than our present months, considerable might be learned about weather sequence that is now hidden.

In a good many States abnormal weather in January is a fair indication of the weather of February, June of July, July of August, December of January, the autumn of the following winter, etc. In Iowa, and perhaps in some other States,[1] June is a key to the rest of the summer.

The data here used are the State averages and departures from normal published in the monthly State section reports. Careful analysis of these data shows that *the greater the abnormality the more certain the sequence* which adds much to the practical usefulness of the study.

Illinois data for June and July temperature and precipitation are graphically presented in figure 1. Among other things these data show:

In 7 out of 10 cases when June averaged 3° or more above normal, July temperature averaged above normal. There was only one case with June temperature 4° or more above normal, and it was followed by July temperature above normal.

In 8 out of 11 cases when June temperature averaged 3° or more below normal, July temperature also averaged

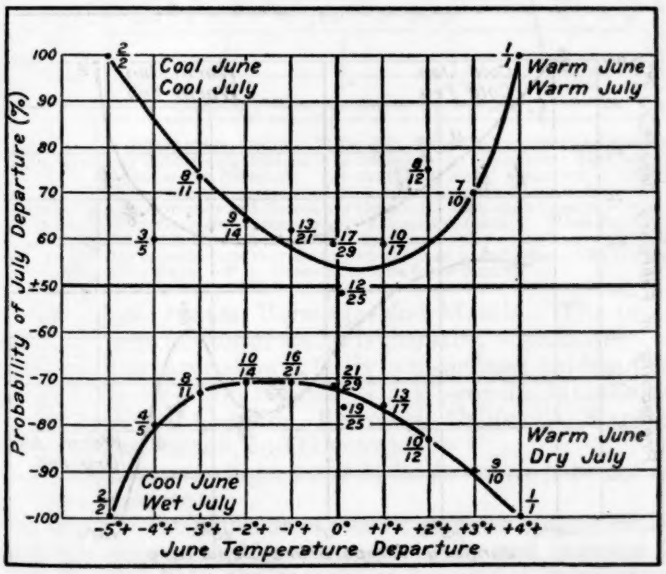


FIGURE 1.—The upper curve shows the frequency and direction of July temperature departures as related to temperature departures of the preceding June in Illinois. The entry, 7/10, means 7 cases out of 10, or 70 percent, probable frequency, represented by a dot. The lower curve shows the frequency and direction of precipitation departures in July as related to temperature departures of the preceding June. When the departures of June and July have the same sign, they are plotted as plus probabilities; when they have opposite signs they are plotted as minus probabilities. The entry at the bottom of the graph, —3°+, means 3° or more below normal.

below normal. There are only 2 cases when June temperature averaged as much as 5° or more below normal, and in each case July also averaged below normal.

In 13 out of 17 cases when June temperature averaged 1° or more above normal, July precipitation averaged below normal. In 10 out of 12 cases when June temperature averaged 2° or more above normal, July precipitation averaged below normal; and when June temperature averaged 3° or more above normal, July precipitation averaged below normal in 9 out of 10 cases.

In 8 out of 11 cases when June temperature averaged 3° or more below normal, July precipitation averaged above normal; in 4 out of 5 cases when June temperature averaged 4° or more below normal, July precipitation

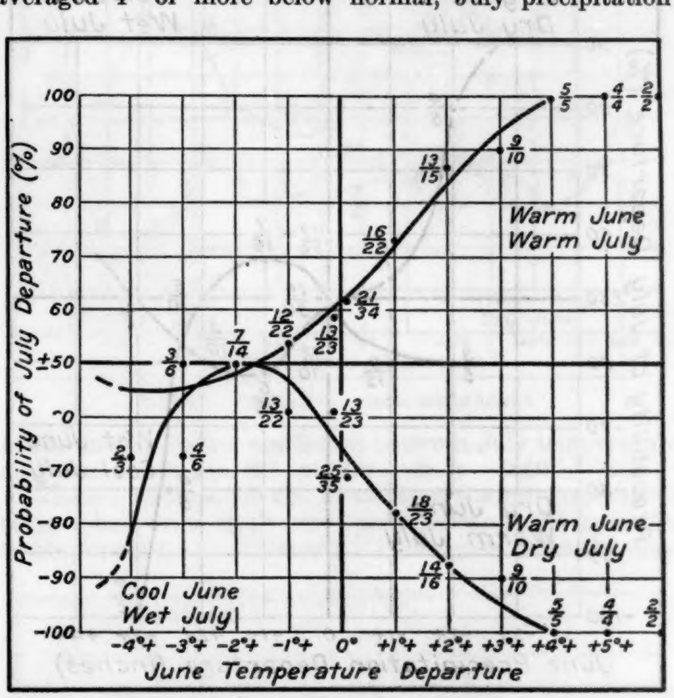


FIGURE 2.—The upper curve shows the frequency and direction of July temperature departures as related to the temperature departures of the preceding June in Iowa. The entry, 13/15, means 13 out of 15 cases, or 87 percent, probable frequency, represented by a dot. The lower curve shows the frequency and direction of precipitation departure in July as related to the temperature departures of the preceding June. When the departures of June and July have the same sign, they are plotted as plus probabilities; when they have opposite signs they are plotted as minus probabilities. The entry at the bottom of the graph, +3° +, means 3° or more above normal.

averaged above normal; and in 2 cases when June temperature averaged 5° or more below normal, July precipitation averaged above normal.

In all of the above cases the greater abnormality was followed by the more certain sequence. The regular appearance of the curves and the very moderate scattering of the dots gives one much confidence in the results. Also, inspection of the June temperature-July temperature curve shows that the lowest percentage of sequence does not come at the normal but 1° or so above normal; and the June temperature-July precipitation curve shows that the lowest probable sequence comes at 1° to 2° below normal rather than at the normal.

In all of the above, temperature was taken as the indicator. If June precipitation be tried as an indicator, the results are not nearly so regular. However, it is noted that there are 3 cases when June precipitation was 3 inches or more above normal, and in each case July precipitation was above normal. June precipitation departures seem to have very little relation to temperature departures of the following July in Illinois.

Within the limits of this paper, it is possible to present but a small portion of the data that have been studied. Figures 2 and 3 are the June-July curves for Iowa. Here

[1] MONTHLY WEATHER REVIEW, June 1925, pp. 249-251.

the June precipitation departure is more of an indicator of July weather than it is in Illinois and it has therefore been reduced to a curve. Only a few features can be pointed out.

In 16 out of 22 cases when June temperature was 1° or more above normal, the following July temperature was above normal; in 13 out of 15 cases when June tempera-

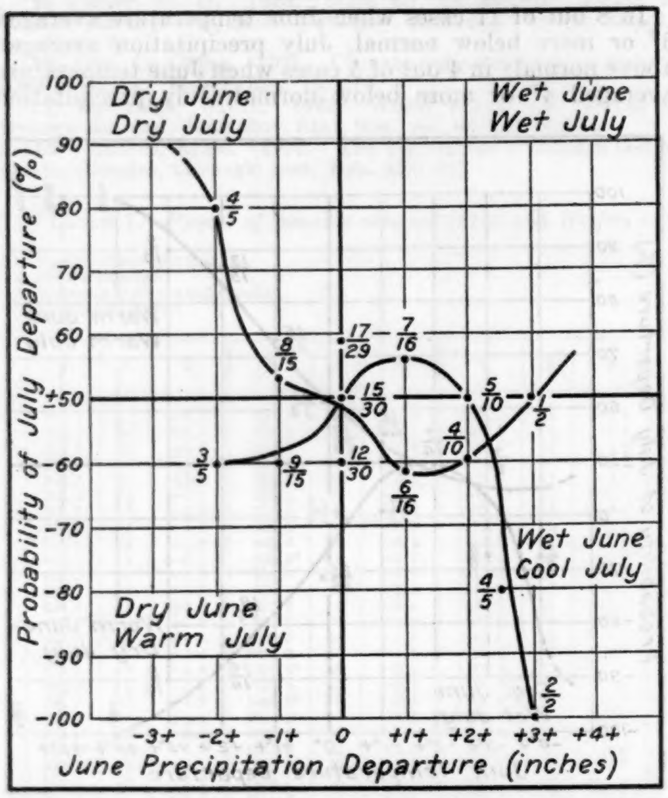


FIGURE 3.—The upper curve shows the frequency and direction of the July precipitation departures as related to the precipitation departures of the preceding June in Iowa. The entry, 4/5, means 4 cases out of 5, or 80 percent, represented by a dot. The lower curve shows the frequency and direction of the temperature departures in July as related to the precipitation departures of the preceding June. When the June and July departures have the same sign they are plotted as plus probabilities; when they have opposite signs they are plotted as minus probabilities. The entry at the bottom of the graph, −1+, means precipitation 1 inch or more below normal.

ture was 2° or more above normal, the following July temperature was above normal; and in 5 cases where the June temperature was 3° or more above normal, July temperature was above normal in every case.

In 5 cases when June temperature was 4° or more above normal, July was drier than normal every time; in 9 out of 10 cases when June temperature was 3° or more above normal, July was drier than normal; and in 14 out of 16 cases when June was 2° or more warmer than normal, July was drier than normal. When June is abnormally cool, the probability of a wet July is only about 67 percent.

In 4 out of 5 cases when June precipitation was 2.5 inches or more above normal, the average temperature of the following July was below normal, and in 4 out of 5 cases when June rainfall was 2 inches or more below normal, the following July was dry (fig. 3).

Along similar lines, outstanding June-July relationships have been noted in North Dakota, Minnesota, Wisconsin, Indiana, Michigan, New England, Kansas, Missouri, South Dakota, Tennessee, Florida, Oregon, and California. One broad statement can be made, namely, that when June temperature averages 3° to 4° above normal, July precipitation will average below normal nearly 100 percent of the time over much of the Mississippi Valley—a matter of importance in respect to corn and cotton.

In Iowa, June temperature above normal is a good indication that the average temperature of the next 3 months will be above normal.[2] This applies 70 to 78 percent of the time from Calgary, North Dakota, and Minnesota to Missouri and east to Ohio, and in Nebraska. In the five cases in Iowa when July was 4° or more above normal in temperature, the following August was above normal in temperature in each case and when July was 4° or more below normal in temperature, August was below normal in each of 3 cases. Also when July has been as little as 1° or more above normal in temperature, August has been drier than normal in 18 out of 22 cases. When July rainfall was 2 inches above normal, August rainfall was above normal in 6 out of 8 cases, and when 2 inches below normal, August was below normal in 5 out of 6 cases. There is a well defined tendency for abnormal July weather to perpetuate itself in August in Iowa, northern Illinois, and possibly elsewhere.

Another sequence worthy of study is the January-February relationship which is of much importance in some States. Here again the greater the abnormality the more certain the sequence.

Figure 4 shows the curves for Iowa using temperature as an indicator. A cold January is more likely to be followed by a cold February than is a warm January by a warm February. In 14 out of 19 cases when January was 4° or more below normal in temperature, it was followed by a February below normal in temperature. This sequence is higher as the Januarys are colder, reaching 5 cases out of 5 at 10° below normal. At 9° above normal, January is followed by a warm February 3 out of 4 times, and in each of the 2 cases of 10° above normal. A cold January has little significance as to precipitation in February, but a January, 8° or more warmer than

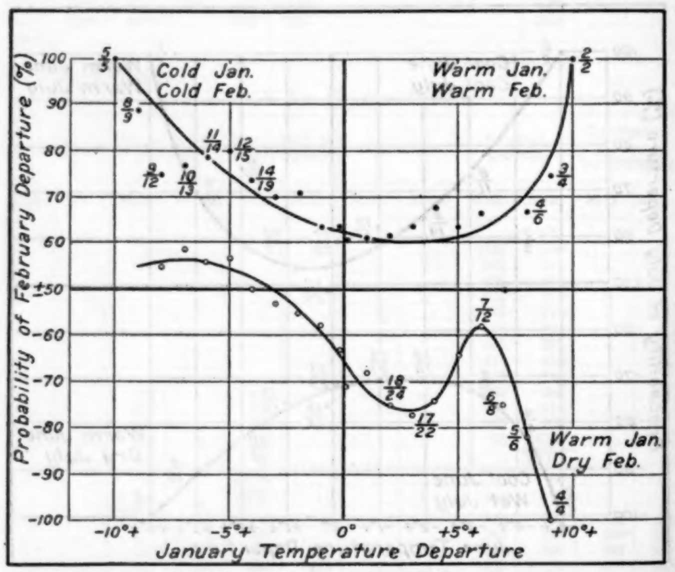


FIGURE 4.—The upper curve shows the frequency and direction of the February temperature departures as related to the temperature departures of the preceding January in Iowa. The entry, 12/15, means 12 cases out of 15, or 80 per cent, probable frequency, represented by a dot. The lower curve shows the frequency and direction of precipitation departures in February as related to the temperature departures of the preceding January. When the departures of January and February have the same sign they are plotted as plus probabilities; when they have opposite signs they are plotted as minus probabilities. The entry at the bottom of the graph, −5°+, means 5° or more below normal.

normal, is followed by a dry February 5 times out of 6, and in all of the 4 cases of 9° above normal. January and February temperature abnormalities have a tendency to persist through March in Iowa.

Precipitation in January, 0.75 inch or more above normal, in Iowa, has been followed by a February colder

[2] MONTHLY WEATHER REVIEW, June 1925, pp. 249–251.

than normal in 4 out of 5 cases, probably due to a persistent snow cover carried over from January into February which would increase radiation.

Similar results are obtained from a study of Wisconsin data (fig. 5). Here a Janaury 4° or more above normal has been followed by a warm February 9 out of 11 times, and a January 6° or more below normal by a cold February 6 out of 7 times. Both excessively cold and excessively warm Januarys have a tendency to be followed by dry Februarys, due to the fact that the normal precipitation of February is made up of a relatively small number of heavy amounts and a large number of small amounts; that is, 65 percent of the Februarys have had below-normal precipitation.

Cold Januarys show marked tendencies to be followed by cold Februarys from the upper Mississippi east over the Great Lakes, Indiana, Ohio, and Pennsylvania; also

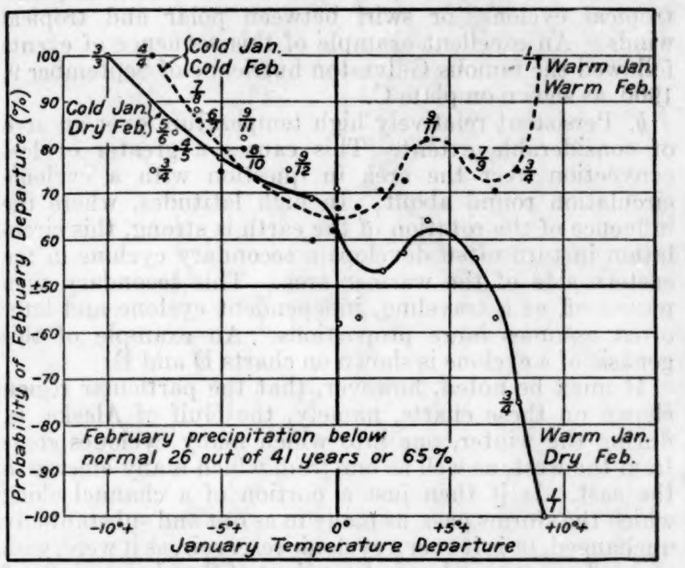


FIGURE 5.—The broken curve, drawn to fit the dots, shows the frequency and direction of the February temperature departures as related to the temperature departures of the preceding January in Wisconsin. The entry, 9/11, means 9 cases out of 11, or 82 percent, probable frequency, represented by a dot. The curve drawn to fit the small circles shows the frequency and direction of the precipitation departures in February as related to the temperature departures of the preceding January. When the departures of January and February have the same sign they are plotted as plus probabilities; when they have opposite signs they are plotted as minus probabilities. The entry at the bottom of the graph, −5° +, means 5° or more below normal.

in the Pacific States, Bermuda, and Manila. The proximity of large bodies of water is probably significant.

Warm Januarys show a fairly well-defined tendency to be followed by warm Februarys in Wisconsin, Minnesota, Indiana, North Carolina, Bermuda, California, Kansas, Texas, Sitka, Berlin, and Greenwich.

The May curves (figs. 6 and 7) for Iowa are here shown without comment.

Whatever the cause or causes of extreme abnormalities may be, they probably set in gradually and increase in intensity till both the records and personal impressions register the unusualness after which it takes a period of similar length with decreasing intensity to return to normal. Being aware of the first disturbing half of the abnormality, the reasonable thing is to expect the other restoring half in a similar period. When a temperature abnormality has accumulated a large departure extending over a 30-day period it is easy to predict another 30-day period of restoration, the average of which will have the same sign of departure as the first month. This seems to happen most frequently in midwinter and midsummer. If shorter period data were in convenient form, no doubt many other useful things might be discovered. For example, it is known that when the first two weeks of June are considerably above normal in temperature at Des Moines, the next two weeks are likely to be above normal. In summer, precipitation abnormalities are usually in the opposite direction from temperature abnormalities. In

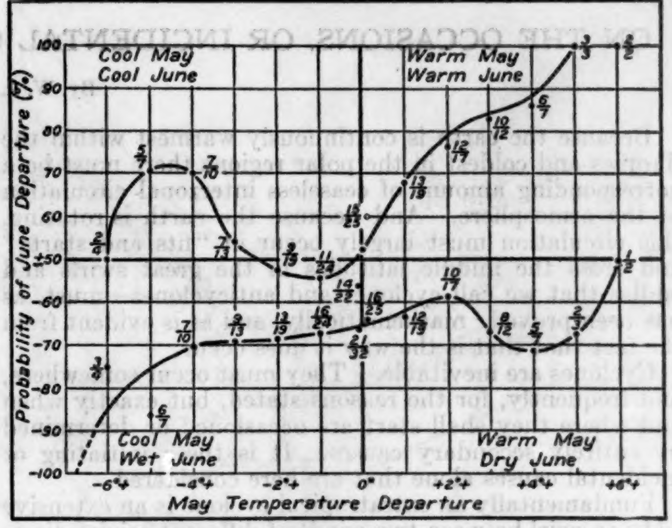


FIGURE 6.—Explanation similar to that of figure 1.

Iowa, the correlation coefficient between July temperature and precipitation in the same month is −0.50.

When conditions are abnormal the meteorologist is most often asked what these conditions portend. It is useful to the forecaster to know that the more extreme the conditions, the more certain are the sequences. Practical applications of these things are left largely to the imagination of the reader. In Iowa, up to July 14, 1931, the season had been almost ideal for corn, but this study made possible the statement that "42 years of carefully recorded experience of the Iowa Weather and Crop Bureau show

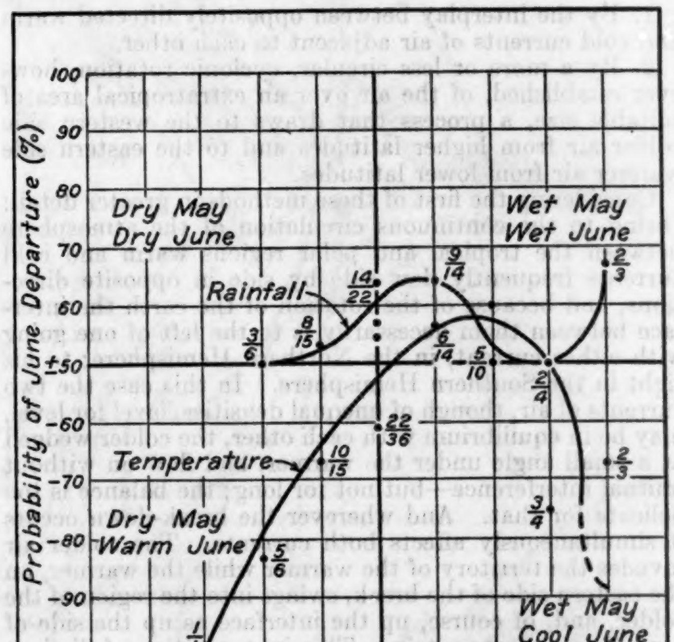


FIGURE 7.—Explanation similar to that of figure 3.

that only once, 1921, has a large yield followed such a set of circumstances, so deterioration may be expected to set in soon." Following that date, the Bureau of Agricultural Economics of the United States Department of Agriculture showed a reduction of more than 100,000,000 bushels in the estimate of the Iowa corn crop. Such a thing is of vast agricultural and commercial importance. Thus at the close of an abnormally cold January, it would be the best sort of business sense to keep train loads of fuel moving into Iowa. Again a mild January indicates a large number of eggs going to market from Iowa in February and a cold January the reverse.

ON THE OCCASIONS, OR INCIDENTAL CAUSES, OF EXTRATROPICAL CYCLONES

By W. J. HUMPHREYS

Because the earth is continuously warmest within the Tropics and coldest in the polar regions there must be a corresponding amount of ceaseless interzonal circulation of the atmosphere. And because the earth is rotating, this circulation must largely occur in "fits and starts" and cross the middle latitudes in the great swirls and eddies that we call cyclones and anticyclones—must, as has been proved [1] mathematically, and as is evident from the fact that that is the way it does occur.

Cyclones are inevitable. They must occur somewhere, and frequently, for the reasons stated, but exactly when and where they shall start are occasioned or determined by entirely secondary causes. It is these initiating or incidental causes alone that are here considered.

Fundamentally an extratropical cyclone is an extensive eddy or swirl between two winds of different origin, direction, and temperature. Such winds are always blowing. They are the mutually compensating branches of the continuous, interzonal circulation between the warmer and colder portions of the earth. But how are they brought each so decidedly under the influence of the other that an eddy is established between them?

This is effected:

1. By the interplay between oppositely directed warm and cold currents of air adjacent to each other.

2. By a more or less circular, cyclonic rotation, however established, of the air over an extratropical area of suitable size, a process that draws to the western side colder air from higher latitudes and to the eastern side warmer air from lower latitudes.

Considering the first of these methods in greater detail: Owing to the continuous circulation of the atmosphere between the tropical and polar regions warm and cold currents frequently flow side by side in opposite directions, and because of the rotation of the earth the interface between them necessarily is to the left of one going with either current, in the Northern Hemisphere; to his right in the Southern Hemisphere. In this case the two currents of air, though of unequal densities, level for level, may be in equilibrium with each other, the colder wedged at a small angle under the warmer, and flow on without mutual interference—but not for long; the balance is too delicate for that. And wherever the break-down occurs it simultaneously affects both currents. The colder air invades the territory of the warmer while the warmer, on the eastern side of the break, swings into the region of the colder, and, of course, up the interface as up the side of a gently rising mountain. This juxtaposition of distinct air currents occasions most of the extratropical cyclones, and is effective wherever such storms occur. This action is well illustrated by charts A and B.

The second of the two general methods of starting the extratropical cyclone, listed above, may be variously subdivided. One such division is:

a. The invasion of extratropical regions by a cyclone of tropical origin. In this case a continuous storm path may be traced, but not a track of a continuous storm, in the sense of one having all the time the same characteristics. Once it was a mighty whirl in a mass of air of common origin and of substantially the same temperature and humidity on every side, but later, at higher latitudes, and where the conditions already were favorable, it gradually *occasioned* (did not develop or transform into) an extratropical cyclone, or swirl between polar and tropical winds. An excellent example of this sequence of events followed the famous Galveston hurricane of September 9, 1900, as shown on plate C.

b. Persistent relatively high temperature over an area of considerable extent. This causes a greater or less convection over the area in question with a cyclonic circulation round about. In high latitudes, where the influence of the rotation of the earth is strong, this circulation in turn often develops a secondary cyclone in the eastern side of the warmer area. This secondary then moves off as a traveling, independent cyclone and later often assumes large proportions. An example of this genasis of a cyclone is shown on charts D and E.

It must be noted, however, that the particular region shown on these charts, namely, the Gulf of Alaska, is, during the winter, one into which many cyclones come from the west, as well as one from which many emerge to the east. Is it then just a portion of a channel along which the storms pass, as many in as out and substantially unchanged, or is it ever a cyclonic reservoir, as it were, with an outflow more or less independent of the obvious inflow? It is certain that more cyclones leave this region than would if none entered it, and we infer that, owing to its relatively high temperature, the storms leaving it are greater in number than those entering, and commonly different in size and intensity as well—inferences that appear to be abundantly supported by observation. In short, we infer and believe that some of the storms that leave this region had also their origin there, or were occasioned by it.

c. Relatively high temperatures, due to insolation, over land. The cyclones thus induced, "heat" LOWS, they have been called, commonly are feeble and of little importance. A cyclone that appears to have been contributed to in this way, starting as a California valley LOW, is shown on charts F to H, inclusive.

d. The heating of the air over a considerable area by foehn or chinook winds. Charts I to L, inclusive, show a good example of a cyclone initiated in this interesting way.

There is nothing really new in this paper, nevertheless the emphasis on the several examples afforded by the charts may be helpful to at least some students of this daily puzzle, the extratropical cyclone.

I wish here to acknowledge my deep indebtedness to Messrs. G. E. Dunn, assistant to the forecasters, and A. J. Haidle and Welby R. Stevens of the Forecast Division of the United States Weather Bureau, for kindly selecting for me the weather maps used in this article.

[1] Jeffreys, Quart. J. Roy. Meteorol. Soc., 52: 85, 1926.

Chart A.—February 19, 1929, 8 a. m.

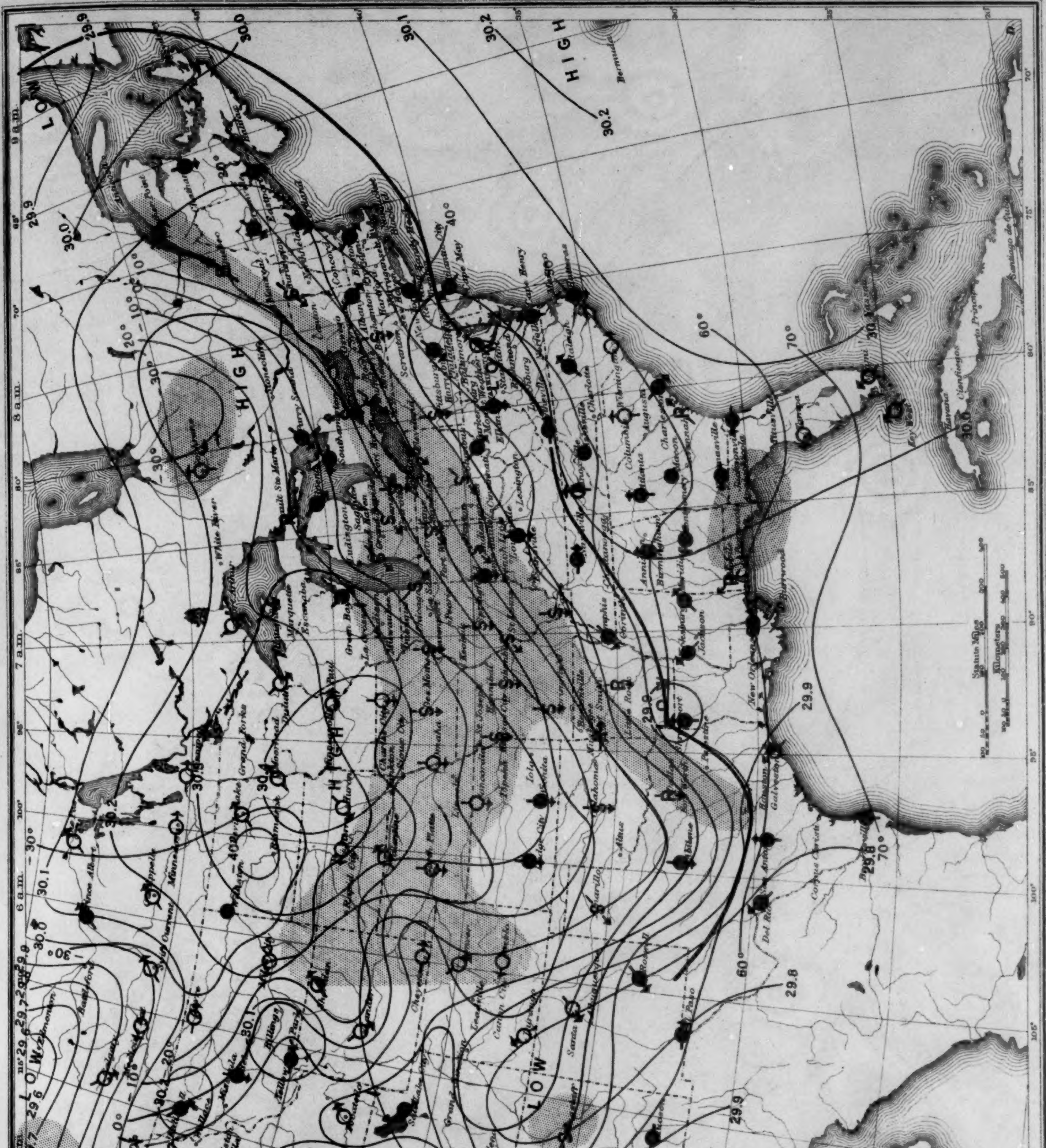


Chart A.—February 19, 1929, 8 a. m.

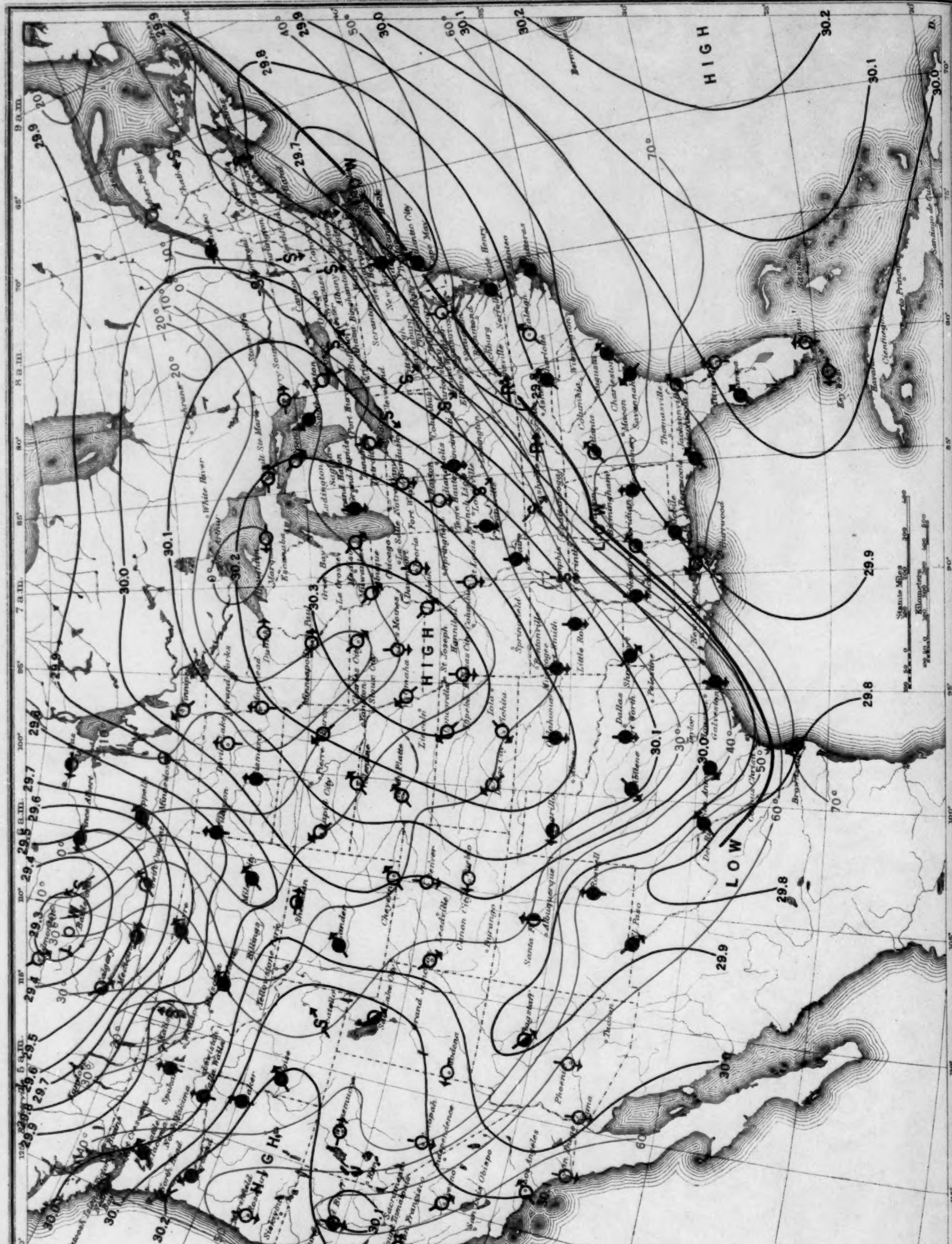


Chart B.—February 19, 1929, 8 p. m.

Chart C.—September 12, 1900, 8 a. m.

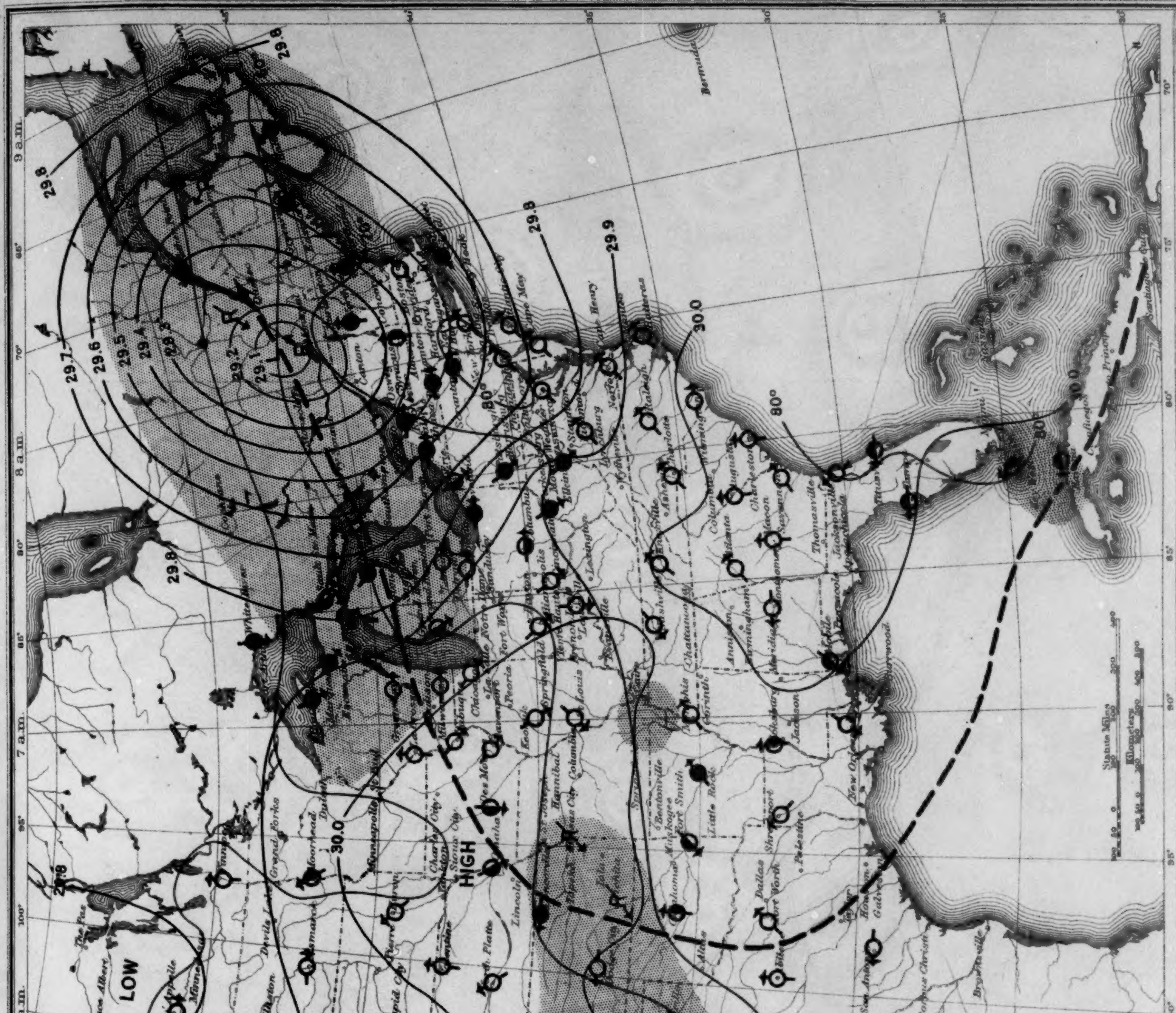


Chart D.—January 4, 1933, 8 a. m.

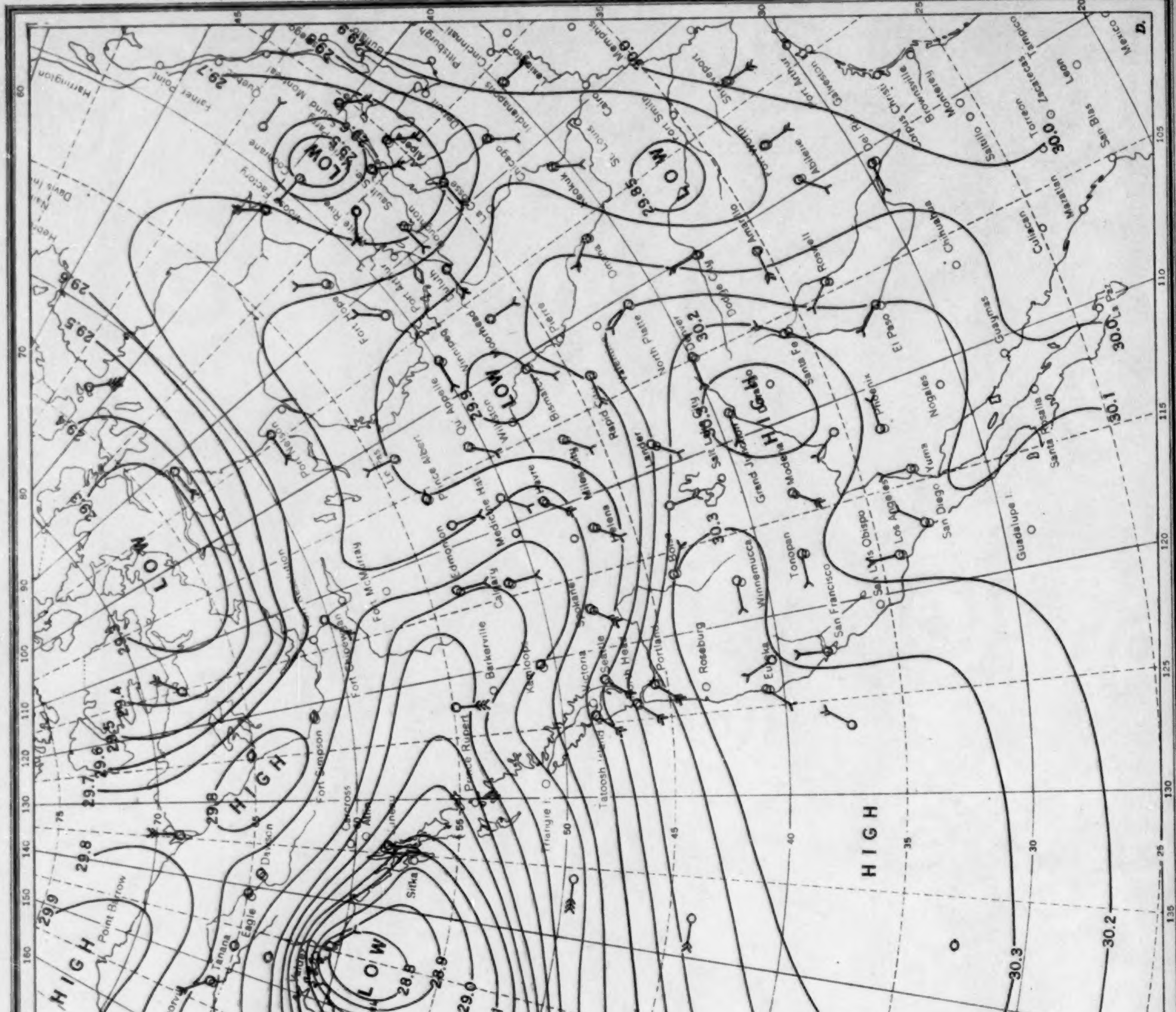


Chart E.—January 4, 1933, 8 p. m.

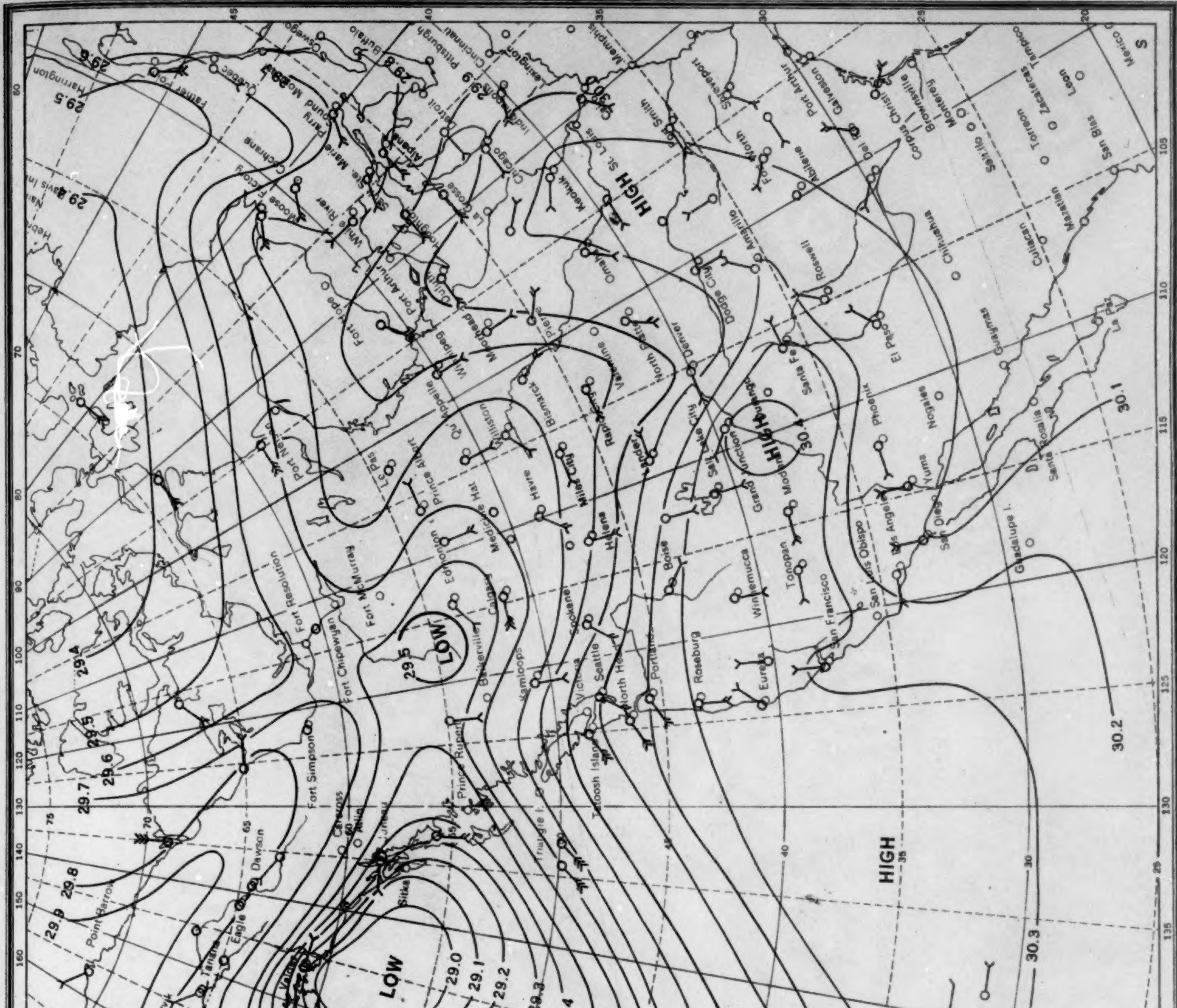


Chart F.—July 1, 1927, 8 a.m.

Chart G.—July 2, 1927, 8 a. m.

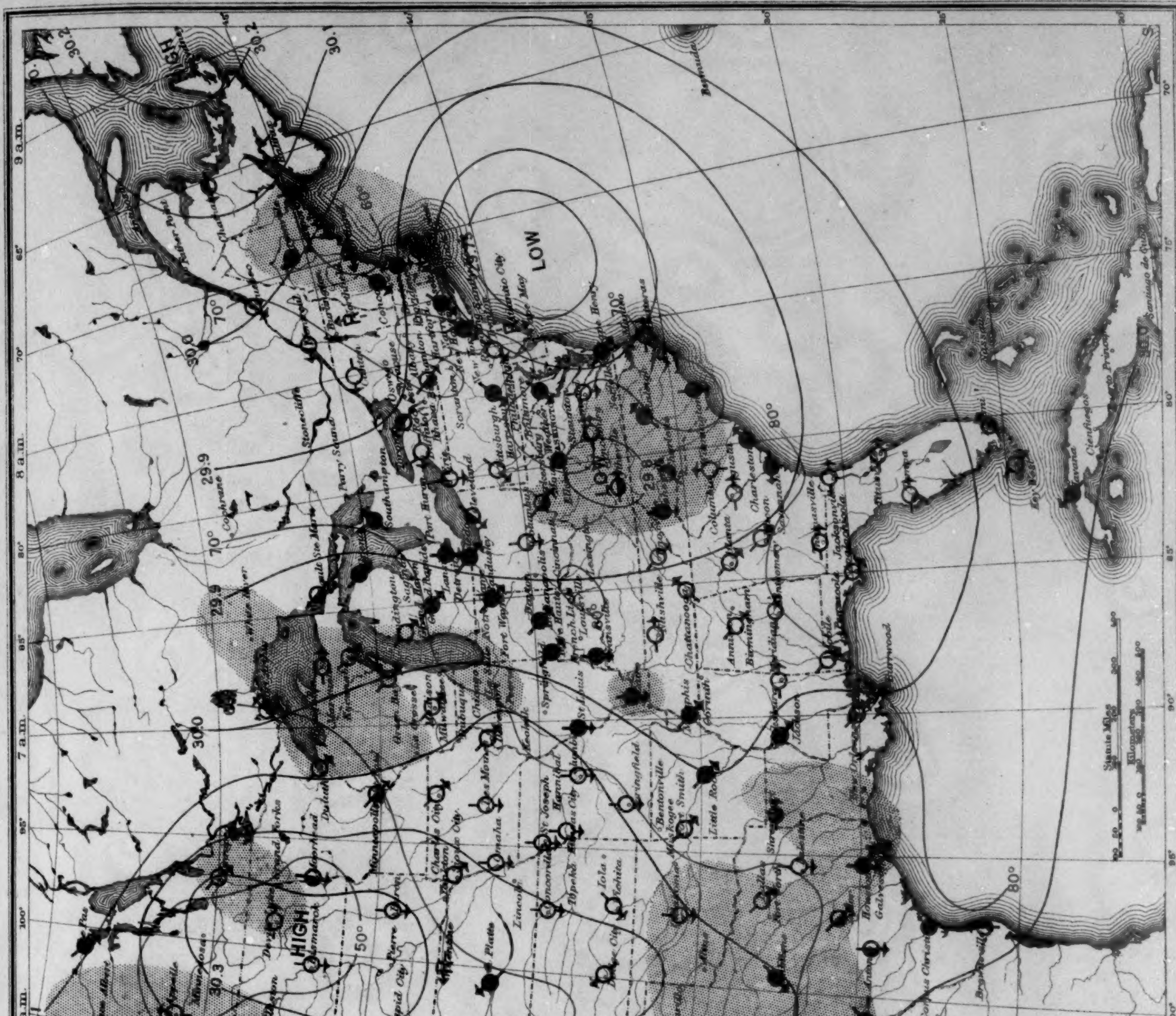


Chart H.—July 5, 1927, 8 a. m.

Chart I.—March 1 1929, 8 a. m.

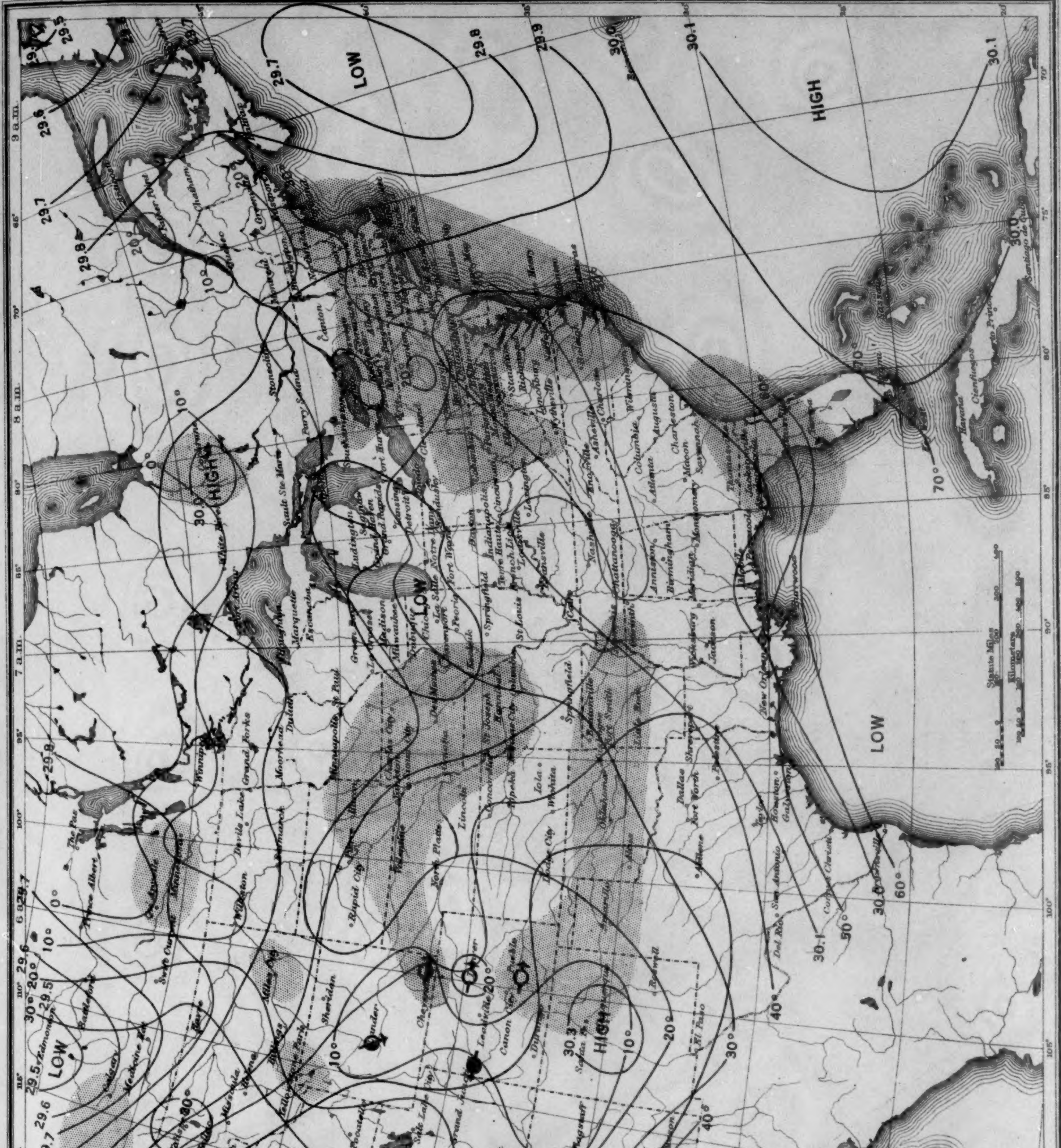


Chart I.—March 1 1929, 8 a. m.

Chart J.—March 1, 1929, 8 p. m.

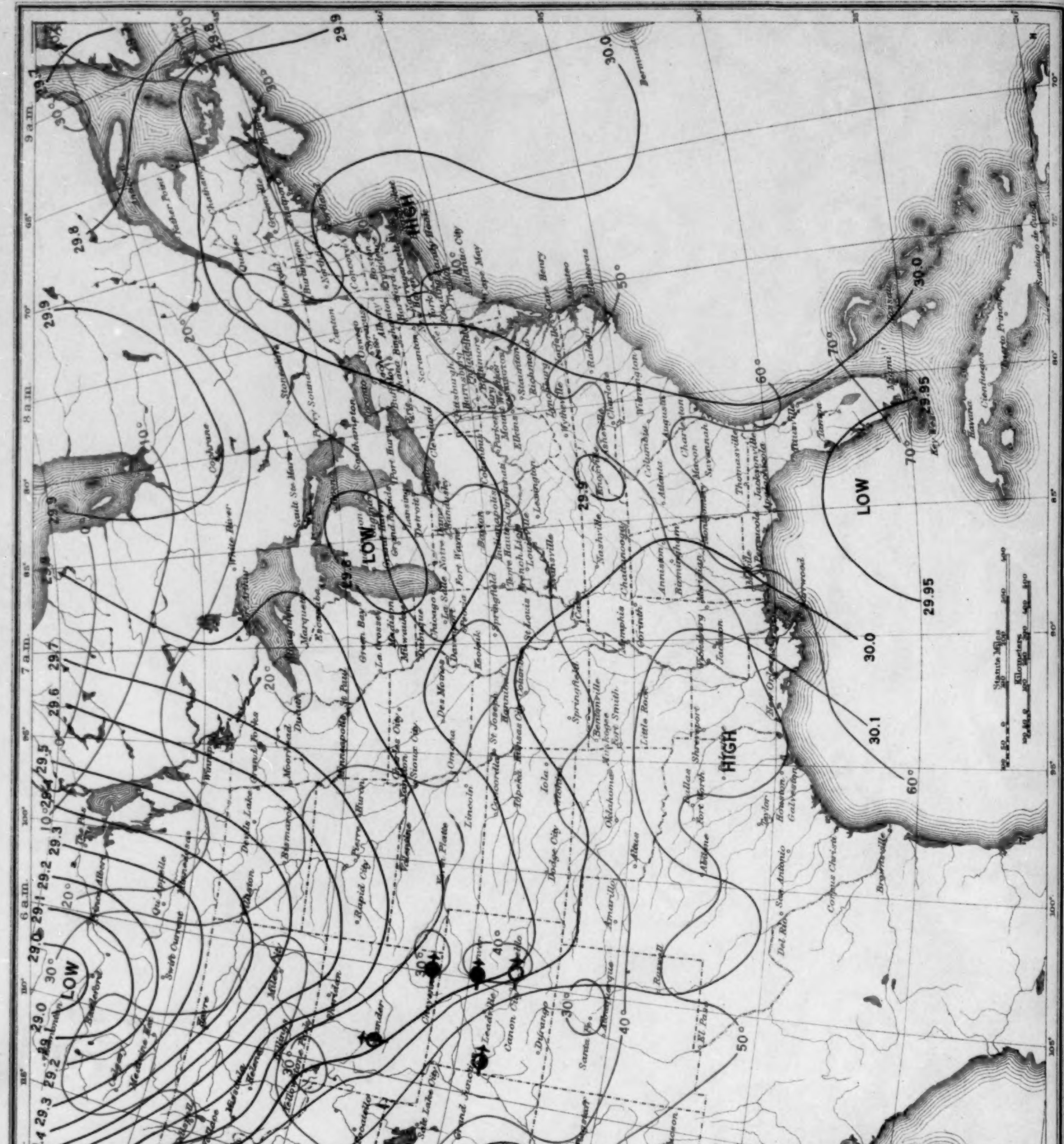


Chart K.—March 2, 1929, 8 a. m.

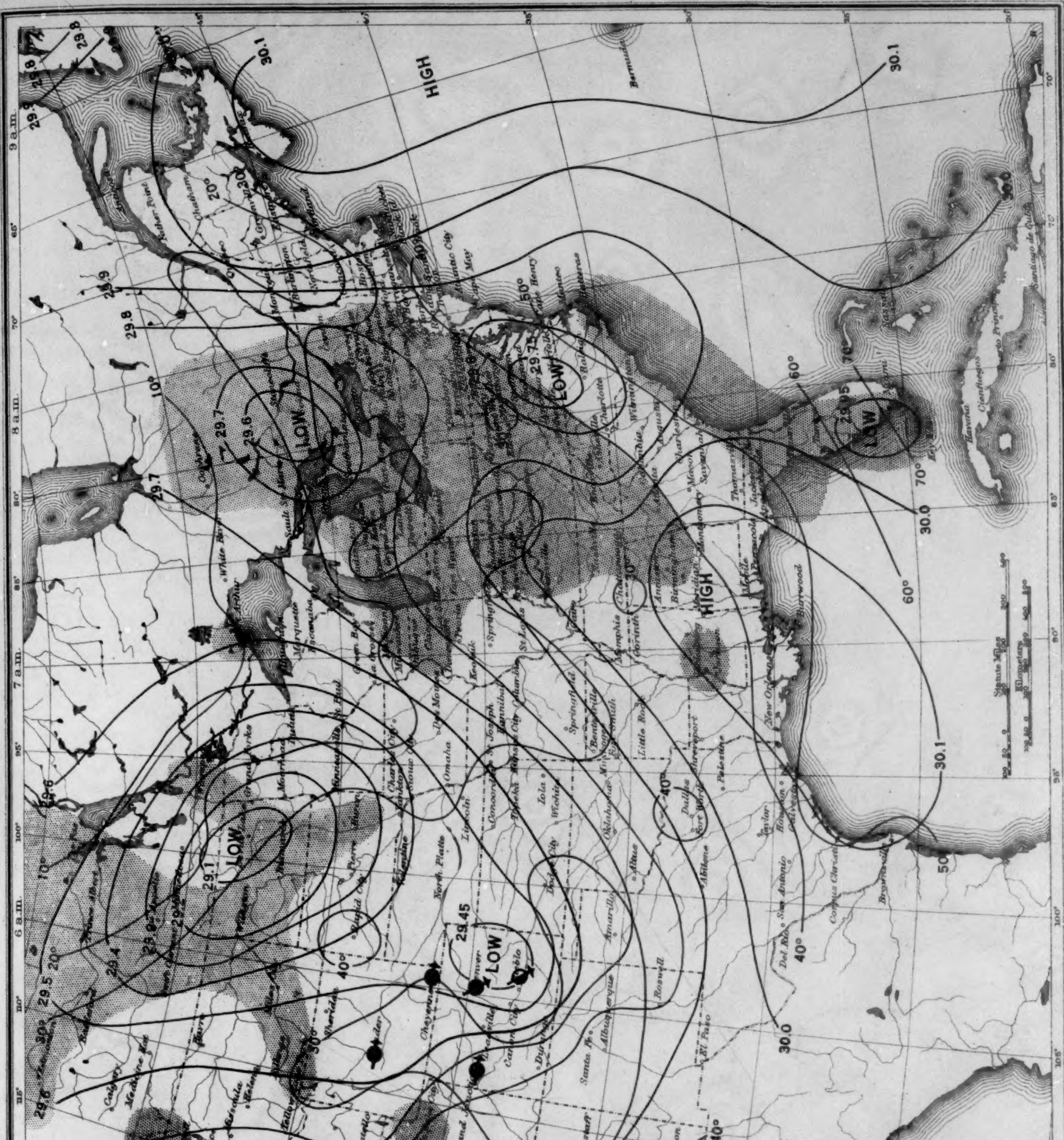
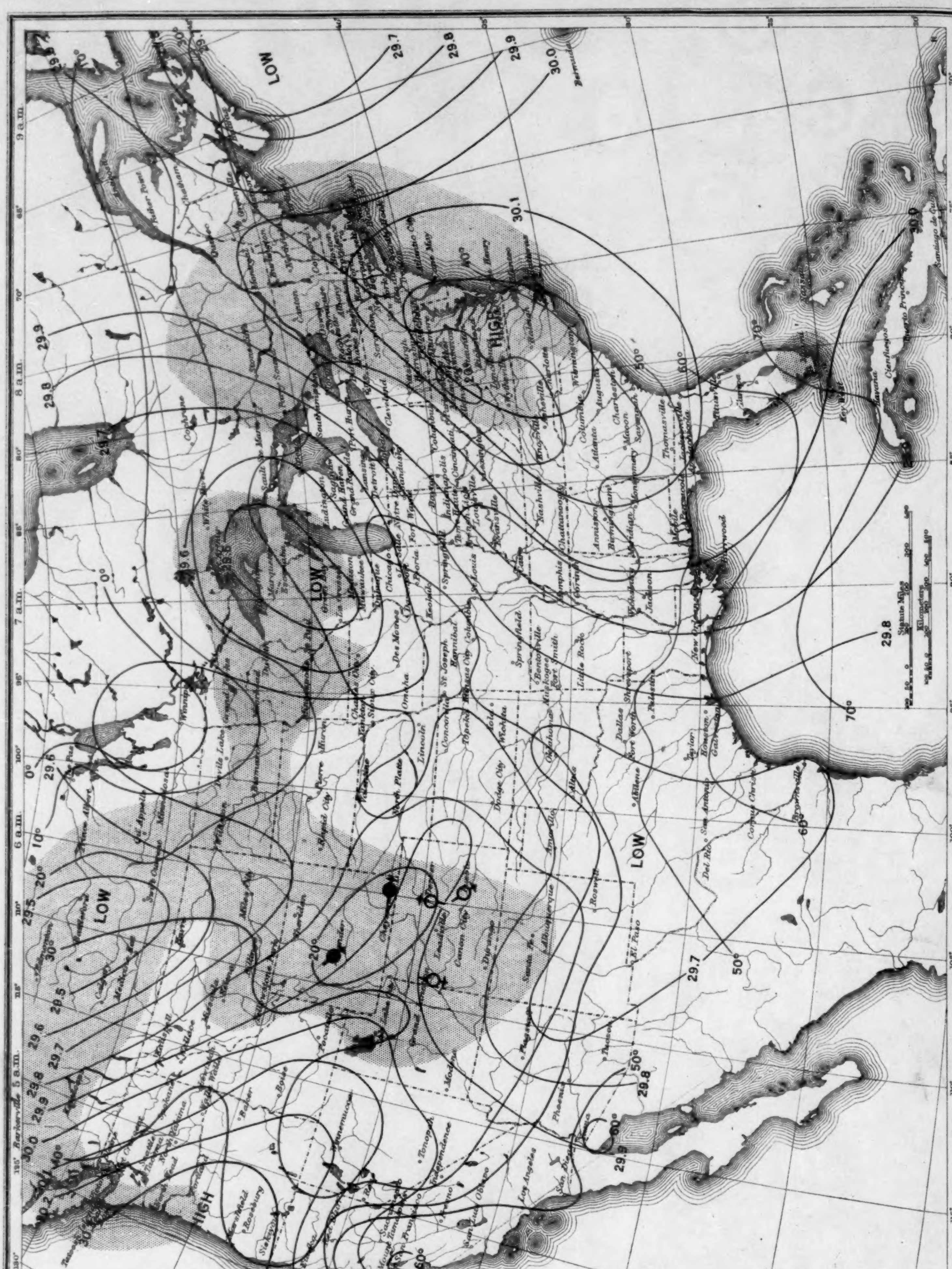


Chart L.—March 3, 1929, 8 a. m.



AN UNUSUAL TEXAS DUSTSTORM, MARCH 24-25, 1933

By MALCOLM C. HARRISON

[Weather Bureau Airport Station, Dallas, Tex.]

An unusual duststorm occurred over North and Central Texas on the night of March 24-25, 1933.

Dust and sandstorms often occur over West Texas, most frequently over the Panhandle and Llano Estacado, or Staked Plains,[1] where semiarid conditions exist, and also, but less often, over Central Texas. Pilots flying north or west out of Dallas are familiar with this phenomenon, and know what it is to fly through, go around, or even turn back and await the passing of, the storm. But every pilot who flew, or attempted to fly, through this particular duststorm reported his experience as unique.

The evening map of March 22 showed that a circular LOW was developing over Nevada. By the morning of the 24th it had moved east by slightly south with center just east of the Continental Divide and with axis elongated north and south. During the next 12 hours it moved rapidly east-southeast with trough lengthening and extending in a semi-arc from North Dakota southward through western Missouri and Southwest Texas into Mexico. By 7 a.m. (C.S.T.) of the 25th it had recurved rapidly northeastward and was centered over the Great Lakes, leaving the Southwest under the control of a Pacific HIGH.

No precipitation resulted from the movement of this LOW in those areas where the greatest supply of dust and sand is to be found, viz, Arizona, New Mexico, western Oklahoma, the western half of Texas, the northwest portion of East Texas, and other relatively dry regions of the far Southwest. A better meteorological condition could not exist for the formation of duststorms over North and West Texas and West and Central Oklahoma, especially at that season of the year.

The wind shift reached El Paso in extreme West Texas about 9 a.m., and Amarillo in the Panhandle about 11 a.m. Moving rapidly eastward, it reached Oklahoma City at 6 p.m. and Dallas at 8:40 p.m. of the 24th, attended by locally thick dust over its north portion and with thunderstorms along its entire front upon approaching the Dallas-Oklahoma City-Wichita airway. The wind shift itself caused only local puffs of dust in Texas (exclusive of the Panhandle). Stations reported visibilities of 8 to 15 miles and never less than 6 miles with the passing of the shift. The surface winds over the south portion of the shift were moderate while over the north portion they were strong. Within 6 to 8 hours after the passage of the wind shift, the surface winds, together with those in the low levels aloft, had veered from west and northwest to northeast, causing the ground visibilities to show the greatest decrease due to the settling of the dust from aloft.

There are three outstanding peculiarities of this duststorm; (*a*) Poor visibility aloft with good visibility at the surface, or ground; (*b*) whitish color of the dust, and (*c*) fineness of the dust. Although at various times the surface visibility decreased to 1 mile or less over the Panhandle and western Oklahoma, it never reached less than 7 miles from Dallas north to the Red River, and ranged from 4 to 10 miles (mostly 7 miles) from Dallas west to near the Guadalupe Pass in the mountains of extreme West Texas, followed by a visibility of 2 miles from Big Spring to Guadalupe Pass during the morning of the 25th. This is not in accord with conditions generally found in duststorms as the surface visibility usually is as poor as that aloft. At the 10 p.m. pilot-balloon ascension at Dallas the lantern was completely obscured within 4 minutes (altitude 2,600 feet above the ground), with a surface visibility of 10 miles; the next morning at the 5 a.m. ascension the lantern was obscured within 8 minutes (altitude, 5,000 feet), with a surface visibility of 8 miles.

Pilots reported this dust as being very fine and white in color, while ordinary duststorms over this area are composed of a heavy dust or sand of a yellowish or reddish-brown color. One pilot stated that the dust gave him a choking sensation and at times he was unable to read his instruments; another, enroute from Fort Worth to Dallas, flying at an altitude of 600 feet, had to search diligently for the Dallas airport, where the surface visibility was 10 miles. Other pilots were experiencing the same conditions elsewhere over North and Central Texas, all groping about more or less blindly, flying by instruments in a sea of white dust, with the stars dimly shining above and the ground stations reporting visibilities which seemed to belie the conditions aloft. One veteran pilot, who had previously made his customary call at the local Weather Bureau Office before departing on his flight, returned within a few hours and asked what was the matter with the weather. He was plainly baffled by this mysterious element, which he had failed to recognize as dust, due to its white color.

The experiences of two pilots on this night will be given somewhat in detail in order to bring out more clearly the conditions encountered—Pilot L. R. Wallace to the westward and Pilot E. C. Rockwood to the northward:

Pilot Wallace, flying the Dallas-El Paso section of the southern transcontinental airway, encountered the dust at the Pecos River near 6 p.m., while flying eastward out of El Paso. The dust gradually thickened in both density and depth, when Wallace pulled his ship up to an altitude of 9,000 feet where he flew all the way to Big Spring in order to avoid the dust which had a very irregular and ill-defined top near this elevation. From Big Spring to Abilene he flew through the dust at 1,500 feet with a visibility of 8 miles. On leaving Abilene, with Fort Worth-Dallas his next and final stop, he pulled up to an altitude of 4,000 feet where the top of the dust was definite and sharp. Out of Abilene the visibility became rapidly less with beacons visible 2 miles at an angle, and the lights of towns seen only when the ship was directly over them. However, it should be remembered that the pilot was looking downward through a layer of dust roughly a mile thick.

Within an hour the pilot had gone as far east as Ranger, circled three times over the dim lights of that town and, after requesting and receiving orders from the operations office of his company in Dallas via radio, he returned to Abilene. During this time the visibility aloft had decreased from 8 miles to, generally, from one-half to 1½ miles.

The west bound mail out of Dallas was entrained at Fort Worth, after Pilot J. H. Mangham was forced to return there after flying only a short distance on his way to El Paso. At 4 a.m. Pilot Wallace picked his mail up at Abilene and once more turned westward with Big Spring and El Paso his destination. This was after the eastbound mail had been entrained for Fort Worth-Dallas out of Abilene. On the westward trip the ship

[1] Region immediately south of and adjoining the Panhandle.

was flown at approximately 500 feet, taking advantage of moderate northeast winds, from Abilene to Guadalupe Pass, with the visibility averaging 2 miles, until reaching Guadalupe Field (20 miles east of Guadalupe Pass) where there was a change within 1 mile from a visibility of 2 miles to 60 miles north, south, and west. Guadalupe Field was reached just at dawn.

Pilot Rockwood, flying the Dallas-Kansas City section of the Dallas-Chicago route, departed from Dallas 11 p.m. with the surface visibility 10 miles, while at an altitude of 500 feet he found it to be less than 1½ miles. The base of the dust was fairly sharp at this elevation. Within 15 minutes he was forced back to Dallas after encountering an unusually heavy wave of dust which he described as a "white wall of something that looked like fog", and was within one-half mile of the Dallas airport before being able to see the lights from a height of 500 feet.

At 4 a.m. the following morning Pilot Rockwood again departed from Dallas in an endeavor to complete his schedule. He pulled up to an altitude of 1,000 feet flying in the dust, which had somewhat diminished, with a visibility of from 2 to 3 miles to Fort Worth. From Fort Worth to the Red River he flew at 800 feet with a visibility of about 2 miles but, after crossing the Red River Valley, it became unlimited within a distance of 3 miles. No definite base of the dust was noticed on this flight.

J. A. Riley points out [2] that one distinct type of Texas duststorm is caused by strong winds blowing across the plains of Texas, sometimes attaining gale force, over a wide area and picking up large quantities of dust. This would account for the duststorm under consideration except for the fact that the color and fineness of the dust, together with good surface visibility, would indicate that all, or practically all, of it originated somewhere to the west of Texas.

G. M. French, of the Weather Bureau Airport Station at Burbank, Calif., states that—

there were two periods previous to the night of the 24th and 25th of March when strong to gale force surface winds occurred in many localities from eastern California to New Mexico including southern Nevada and southern Utah. One period was on the 21st and morning of 22nd and the other, more severe, on the 23rd.

There are a number of places in eastern California, the southern portions of Nevada and Utah, and in Arizona where dry lakes are composed of alkali, and during windy weather a fine white dust is picked up over these dry lakes.

It would seem from the foregoing that this dust was transported aloft by strong to gale force westerly winds after being picked up in small quantities over dry "alkali lakes" in the region between the Sierras and the southern Rockies and, after crossing the Rockies, more alkali was raised, by locally severe surface winds, from New Mexico and, eventually, upon reaching the Llano Estacado of Texas probably a last reinforcement of white alkali was received from the several dry alkali lakes in this area. As this dust was borne aloft into Central and North Texas (over descending topography, which would be a factor in maintaining good surface visibility) it was allowed gradually to descend to the ground with the veering of the surface winds, which, seemingly, grasped it from the overrunning dust-laden westerlies.

[2] Sandstorms in Texas, MONTHLY WEATHER REVIEW, January 1931, vol. 59, p. 30.

HAZE CONDITION AT NEW ORLEANS, LA., MAY 5–9, 1933

By GEORGE L. CANADAY
[Weather Bureau, New Orleans, La.]

The strange appearance of the sun and moon over New Orleans from May 5 to May 9, 1933, due to an unusually large amount of dust particles in the air, caused a great deal of interest among the residents of that city and resulted in the Weather Bureau answering numerous requests for an explanation of the phenomenon.

The sun, as well as the moon at night, assumed the appearance of a reddish disk. The reflected sunlight was of a mellow, golden color, particularly at dawn and in the late afternoon. Individuals were able to look directly at the rising or sinking sun, without injury to their eyes, the sun gleaming through the haze as a great red ball. At least one person was heard to confuse the setting sun with the moon, commenting on the enlarged appearance of the moon.

The Weather Bureau first observed a light haze over New Orleans during the night of May 5. The haze continued without a break until the night of May 9, varying from light to moderate and at times becoming almost dense. The gathering dust particles interecepted the shorter wave lengths of the sun's light and permitted the longer wave lengths to predominate in reaching the earth's surface, thereby causing the reddish glow of the sun and the golden sunlight.

Table 1, prepared from a typical upper-air map during the haze period, illustrates the strong westerly winds that prevailed. These high winds aloft probably were responsible for the unusual occurrence at New Orleans, having picked up the dust particles from more elevated, arid regions of the southwestern part of the United States and transported them eastward. The haze condition ended almost simultaneously with the shift of winds from a westerly to a more southerly direction.

TABLE 1.—*Winds aloft, May 5, 1933*

[Direction and velocity (m.p.s.)]

Station	Surface	1,000 M.	2,000 M.	3,000 M.
Albuquerque, N.Mex.	NW-2	WSW-4	W-7	-------
El Paso, Tex.	SW-9	W-16	NW-16	W-19
Big Springs, Tex.	S-1	WNW-3	WSW-12	W-20
Brownsville, Tex.	SW-1	SE-9	NW-2	SSW-15
Houston, Tex.	NW-1	WSW-10	WSW-11	W-22
Dallas, Tex.	W-7	WNW-10	WNW-12	W-14
Jackson, Miss.	SW-4	SW-8	W-18	W-29
New Orleans, La.	SE-1	SW-8	NW-18	WSW-29

While cloudiness at New Orleans was somewhat above normal and rainfall deficient, consistent breaks in the clouds permitted a considerable amount of the peculiar sunlight to come through. These circumstances favored closer observance of the haze effects, which were more pronounced in the early morning and late afternoon. Table 2 gives a history of the cloud conditions, rainfall amounts, and sunshine percentages during the existence of the haze over New Orleans.

TABLE 2.—*Cloudiness, precipitation, and sunshine at New Orleans*

Date	7 a.m.	Noon	7 p.m.	Precipitation	Percent sunshine
May 4	10 St. Cu. SE	9 St. Cu. SE	10 St. Cu. S	T	28
5	Few Ci. St. W	8 A. Cu. SW	Few A. Cu. SW	T	96
6	10 St. E	6 A. St. W	2 A. St. SW	T	47
	10 Lt. Fog E	4 St. Cu. SE	8 St. Cu. SE	-----	-----
7	1 A. St. W	10 St. Cu. SW	9 A. St. SW	0	77
	2 St. Cu. S		1 St. Cu. SW		
8	6 A. St. W	4 A. St. W	10 A. St. SW	0	58
	4 St. Cu. SW	6 St. Cu. SW			
9	9 A. St. SW	8 A. St. SW	7 A. St. SW	0	80
	1 Cu. S	2 St. Cu. SW	3 St. Cu. S		
10	2 Cu. S	2 Cu. S	3 A. Cu. S	0	88
			1 Cu. SE	-----	-----

SUMMARY OF SEA-SURFACE TEMPERATURE DATA FOR 1932

By GILES SLOCUM

The table shows the mean monthly sea-surface temperatures for December 1931 and for the 12 months of 1932 in the Caribbean Sea [1] and the Straits of Florida.[1] For comparison, the latest revised normals for each month and for the year are included. These normals are 13-year means (1920 to 1932, inclusive) and replace [2] the 11-year means published in 1931.

CARIBBEAN SEA

It will be seen that the Caribbean Sea was warmer than normal in every month here summarized except December 1932. The mean temperature for September 1932 was the absolute highest for any month during the 13 years of record. The highest August and October mean temperatures in the 13 years also occurred in 1932. During the other months of 1932, the temperatures were lower than they had been in the same months of 1931, the warmest year of record. The year as a whole was warmer than any other except 1931.

STRAITS OF FLORIDA

The temperatures in the Straits of Florida were in most months of 1932 higher than normal. Lower than normal mean temperatures occurred in April and May, but the 4 months, July to October, inclusive, were almost, though not quite, the warmest of record for these months. The temperature of the year as a whole equaled, within less than a tenth of a degree, that of the warmest of the given 13 years, namely, 1927.

[1] For boundaries of the area, cf. MONTHLY WEATHER REVIEW, January 1932, p. 35.
[2] Cf. Bucket Observations of Sea-Surface Temperature. MONTHLY WEATHER REVIEW, vol. 59, pp. 50, 92, 133, 168, 212, 253, 288, 324, 367, 398, 443, 495.

Table 1.—*Mean sea-surface temperatures (°F.) for December [1] 1931 and for January to December 1932*

Month	Caribbean Sea		Straits of Florida	
	Mean	Normal	Mean	Normal
December 1931	80.6	80.4	78.4	76.6
January 1932	79.6	79.1	76.7	74.9
February	78.7	78.5	76.8	74.7
March	79.4	78.8	75.7	74.9
April	80.0	79.4	75.6	76.7
May	81.4	80.7	78.3	78.8
June	82.2	81.5	81.6	81.5
July	82.4	81.8	84.2	83.2
August	83.5	82.4	84.7	84.0
September	84.0	82.9	84.2	83.5
October	83.7	82.6	82.2	81.5
November	82.0	81.7	79.4	78.7
December	80.3	80.4	77.0	76.6
Year	81.4	80.8	79.7	79.2

[1] December 1931 to April 1932, inclusive, are revised values. Preliminary values, based on incomplete returns were published in the MONTHLY WEATHER REVIEW for these respective months in 1931 and 1932, q.v.

BIBLIOGRAPHY

C. FITZHUGH TALMAN, in Charge of Library

RECENT ADDITIONS

The following have been selected from among the titles of books recently received as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies:

Abbot, C. G.
Forecasts of solar variation. Washington. 1933. 5 p. figs. 24½ cm. (Smith. misc. coll. v. 89, no. 5.)

Brooks, Donald B., & Allen, Heman H.
Some improvements in psychrometry. p. 121–134. figs. 25½ cm. (Journ. Wash. acad. sci., v. 23, Mar. 15, 1933.)

Claxton, T. F.
Isotyphs showing the prevalence of typhoons in different regions of the Far East for each month of the year. Hong Kong. 1932. 2 p. pl. 33½ cm.

Den Hartog, J. P.
Conductor vibration from wind and sleet. p. 240–242. figs. 30 cm. (Elec. engin., v. 52, no. 4, Apr. 1933.)

International commission for the study of clouds.
Atlas international des nuages et des états du ciel. II. Nuages tropicaux. Paris. 1932. 26 p. fig. 25 pl. 32 cm.

Koschmieder, H.
Dynamische Meteorologie. Leipzig. 1933. xii, 376 p. figs. pl. (fold.) 24 cm. (Physik der Atmosphäre. Bd. 2.)

Lunelund, Harald.
Records of solar radiation in Helsingfors. 28 p. figs. 24 cm. (Soc. scient. fenn. Comment. phys.-math. VII. 1.)
Registrierung der Sonnen- und Himmelstrahlung in Helsingfors im Jahre 1930. Berlin. n. d. 57 p. figs. 24 cm. (Soc. scient. fenn. Comment. physico-math. VI. 12.)

Middleton, W. E. Knowles.
Some features of atmospheric eddies with applications to the vibrations of transmission lines. p. 105–113. figs. pl. 25½ cm. (Canadian journ. res., v. 8, Feb., 1933.)

Moore, A. F.
Scouting for a site for a solar-radiation station. Washington. 1933. 23 p. figs. pl. 24½ cm. (Smith. misc. coll. v. 89, no. 4.)

Russell, Richard Joel.
Fixing the facts of climatic distribution. p. 164–170. figs. 26 cm. (Journ. geogr. v. 32, Apr., 1933.)

Sasaki, Tatudirô, & Yosida, Tokurô.
Speedometer which indicates true airspeeds. p. 395–415. figs. 26½ cm. (Report Aeron. res. inst., Tôkyô imp. univ. no. 95. Mar., 1933. (Vol. VII, 14.)

Sverdrup, H. U. & Soule, F. M.
Scientific results of the "Nautilus" expedition, 1931. Under the command of Capt. Sir Hubert Wilkins. pt. 1–3. Cambridge. 1933. 76 p. figs. 28 cm. (Mass. inst. tech., & Woods Hole ocean. inst. Papers in phys. ocean. & met. v. 2, no. 1.) (In continuation of Mass. inst. tech. met'l papers.)

U.S. Bureau of standards.
Code for protection against lightning. Pts. 1–3. (Supersedes Handbook 12, formerly M92.) Issued Dec. 30, 1932. Washington. 1933. x, 93, p. figs. pl. 19 cm. (Handbook, Bur. stand., no. 17.)

SOLAR OBSERVATIONS

SOLAR-RADIATION MEASUREMENTS DURING APRIL 1933

By IRVING F. HAND, Assistant in Solar-Radiation Investigations

For a description of instruments and their exposures, the reader is referred to the January 1932 REVIEW, page 26.

Table 1 shows that solar radiation intensities averaged close to normal at Washington and Lincoln, and slightly above normal at Madison.

Table 2 shows an excess in the total solar radiation received on a horizontal surface at Washington, Lincoln, Chicago, New York, Fresno, and Pittsburgh and a deficiency at all other stations for which normals have been computed.

Table 3 shows marked variations in the values of β on each of the 3 days when these measurements were made, due in large part to incipient cloudiness.

Polarization measurements made on 4 days at Washington give a mean of 54 percent, with a maximum of 63 percent on the 3d. At Madison, measurements made on 6 days give a mean of 59 percent, with a maximum of 61 percent on the 14th. These are slightly below normal for the month at both stations.

TABLE 1.—*Solar-radiation intensities during April 1933*

[Gram-calories per minute per square centimeter of normal surface]

Washington, D.C.

Date	Sun's zenith distance: 8a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A.M.					P.M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm	cal	cal	cal	cal	cal	cal	cal	cal	cal	mm
Apr. 3	5.56			0.76	1.08						4.37
Apr. 5	4.37	0.31	0.42	.60							4.57
Apr. 13	4.37	.81	.91	1.03	1.19	1.52					2.87
Apr. 14	5.56				1.07	1.33					5.37
Apr. 18	7.57					1.31					5.56
Apr. 24	4.57					1.45					2.49
Apr. 26	2.49			1.05	1.20	1.41					2.74
Apr. 27	3.00			.94	1.16						2.62
Apr. 28	6.50				.80	1.30					6.53
Apr. 29	9.14				1.10						9.14
Means		(.56)	(.66)	.88	1.09	1.55					
Departures		−.14	−.12	−.01	+.01	+.19					

TABLE 1.—*Solar-radiation intensities during April 1933*—Con.

Madison, Wis.

Date	Sun's zenith distance: 8a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass: A.M.					P.M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
	mm	cal	cal	cal	cal	cal	cal	cal	cal	cal	mm
Apr. 4	3.81			0.84							3.81
Apr. 11	3.00		0.94	1.12							2.74
Apr. 12	3.45				1.28						3.30
Apr. 15	3.45			.97	1.18	1.41					3.30
Apr. 21	6.27			.94	1.17						7.04
Apr. 22	3.81			1.15	1.31	1.51					3.30
Apr. 24	3.81			.87	1.06						5.36
Apr. 25	3.63					1.54					3.45
Apr. 26	3.99			1.00	1.23	1.58	1.21				2.16
Apr. 27	2.62					1.43					2.16
Means			(.94)	.98	1.20	1.49	(1.21)				
Departures			+.01	−.05	±.00	+.06	+.12				

Lincoln, Nebr.

Date	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
Apr. 3	4.37	0.79	0.90	1.08							4.17
Apr. 7	3.45	.79	.92	1.08							3.90
Apr. 10	3.30					1.51	1.28	1.04	0.92	0.80	3.00
Apr. 11	2.74			1.10	1.32	1.50					2.36
Apr. 17	6.02		.69	.87	1.16	1.47					8.18
Apr. 18	6.50	.59	.74	.92	1.12	1.40	1.08	.81	.62	.52	8.48
Apr. 25	6.02						1.21	1.00	.88	.80	3.81
Apr. 28	6.76	.88	.97	1.08	1.22	1.44	1.24				6.27
Means		.76	.84	1.02	1.20	1.46	1.20	.95	.81	.71	
Departures		+.04	+.01	+.04	±.00	+.02	+.02	−.03	−.04	−.01	

Blue Hill, Mass.

Date	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
Apr. 5	3.6				1.20	1.57	1.21	1.11			2.9
Apr. 10	4.8				1.19	1.47	1.09				4.0
Apr. 20	4.2					1.43	1.16				4.0
Apr. 21	3.1				1.18	1.40					4.8
Apr. 22	4.6						1.26	1.07			2.3
Apr. 24	3.4				1.09	1.36	1.04				4.6
Apr. 26	7.9								0.93		5.6
Apr. 30	7.3						1.00				8.8
Means					1.17	1.45	1.13	1.09	(.93)		

* Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Pittsburgh	Fairbanks	Twin Falls	La Jolla	Gainesville	Miami	New Orleans
	Gram calories per square centimeter												
1933	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
April 2	382	182	404	204	280	568	248	397	472	289	335	407	370
April 9	444	352	487	372	348	628	320	385	(*)	416	268	464	240
April 16	342	335	437	358	346	624	293	348	216	374	530	404	360
April 23	610	547	510	503	486	535	509	437	467	283	522	482	382
	Departures from weekly normals												
April 2	−5	−192	−22	−88	−33	+42	−42		+62	−121	−150	−61	
April 9	+40	−54	+57	+45	+11	+72	−9			−14	−208	±0	
April 16	−81	−62	+11	+28	−10	+60	−62		−236	−58	+7	−71	
April 23	+172	+109	+59	+158	+112	−21	+127		−20	−130	−58	−22	
	Accumulated departures on April 30												
	+3,276	−3,584	−189	+3,563	+2,842	+3,262	+651		−259	−3,829	−7,994	−1,645	

* Defective pyrheliometer.

TABLE 3.—*Solar-radiation measurements, and determinations of atmospheric-turbidity factor, β, Washington, D.C., April 1933*

[Values in italics have been interpolated]

Date and solar hour angle	Solar altitude, h.	Air mass, m.	I_m	I_v	I_r	β	Blueness of sky	Atmospheric dust particles per cubic centimeter	Notes: (skylight polarization, P.) clouds, etc.
Apr. 3			gr.cal.	gr.cal.	gr.cal.				
4:44 a	18-07	3.17	0.711	*0.650*	0.500	0.160		420	
4:35 a	19-12	3.02	.755	.637	*.507*	.140			
4:24 a	21-57	2.66	.946	.674	*.559*	.080			
4:20 a	22-43	2.58	.956	*.676*	.562	.080			
3:34 a	31-18	1.92	1.047	*.757*	.574	.085	5		P=56.6%.
3:27 a	32-33	1.87	1.107	.762	*.578*	.065			
Apr. 13									
5:22 a	13-04	4.34	.877	*.691*	.559	.055		461	
5:18 a	13-50	4.13	.913	.694	*.565*	.045			
5:08 a	15-47	3.64	.971	.709	*.603*	.055			
5:01 a	17-10	3.37	1.031	*.715*	.609	.040			
4:48 a	19-41	2.95	1.041	*.770*	.629	.060			
4:45 a	20-16	2.86	1.051	.773	*.632*	.060			
4:14 a	26-14	2.26	1.158	.829	*.665*	.065			
4:09 a	27-12	2.18	1.171	*.834*	.668	.065			
3:13 a	37-38	1.63	1.256	*.882*	.712	.085			
3:09 a	38-22	1.61	1.264	.888	*.715*	.085			
0:41 a	58-46	1.17	1.458	.932	*.772*	.065			
0:37 a	59-01	1.17	1.447	*.934*	.771	.070			
Apr. 26									
4:50 a	22-00	2.65	1.108	*.884*	.637	.045		502	
4:44 a	23-08	2.53	1.132	.790	*.638*	.040			
3:58 a	32-01	1.88	1.216	.857	*.692*	.070	4		P=45.0%.
3:53 a	33-00	1.83	1.255	*.864*	.697	.070			
2:26 a	48-57	1.32	1.394	*.884*	.762	.070			

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, Superintendent United States Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Perkins, and Mount Wilson observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

Date	Eastern standard civil time		Heliographic			Area		Total area for each day
			Diff. long.	Longitude	Latitude	Spot	Group	
1933	h.	m.	°	°	°			
Apr. 1 (Naval Observatory)	13	11	+64.0	24.1	+5.0	93		93
Apr. 2 (Mount Wilson)	12	50	+78.0	25.1	+5.0	128		128
Apr. 3 (Naval Observatory)	10	40		No spots				
Apr. 4 (Naval Observatory)	11	41		No spots				
Apr. 5 (Naval Observatory)	11	11		No spots				
Apr. 6 (Mount Wilson)	12	25	+22.0	276.5	+3.0		8	8
Apr. 7 (Naval Observatory)	11	6		No spots				
Apr. 8 (Naval Observatory)	10	34		No spots				
Apr. 9 (Mount Wilson)	11	0		No spots				
Apr. 10 (Naval Observatory)	10	56		No spots				

Positions and areas of sun spots—Continued

Date	Eastern standard civil time		Heliographic			Area		Total area for each day
			Diff. long.	Longitude	Latitude	Spot	Group	
1933	h.	m.	°	°	°			
Apr. 11 (Mount Wilson)	11	0		No spots				
Apr. 12 (Naval Observatory)	13	17		No spots				
Apr. 13 (Naval Observatory)	10	35		No spots				
Apr. 14 (Naval Observatory)	11	51		No spots				
Apr. 15 (Mount Wilson)	9	10		No spots				
Apr. 16 (Mount Wilson)	11	0		No spots				
Apr. 17 (Naval Observatory)	13	6	−29.0	79.9	+10.0		62	62
Apr. 18 (Naval Observatory)	10	13	−18.0	79.3	+10.0		62	62
Apr. 19 (Harvard Observatory)	13	13	+9.5	92.0	+14.0		170	170
Apr. 20 (Mount Wilson)	12	30	+8.0	77.6	+10.0	7		
			+18.0	87.6	+3.0		4	11
Apr. 21 (Naval Observatory)	13	49	+22.0	79.7	+11.0		9	9
Apr. 22 (Naval Observatory)	11	59		No spots				
Apr. 23 (Naval Observatory)	13	23		No spots				
Apr. 24 (Naval Observatory)	11	4		No spots				
Apr. 25 (Naval Observatory)	11	47		No spots				
Apr. 26 (Naval Observatory)	10	30		No spots				
Apr. 27 (Naval Observatory)	10	18		No spots				
Apr. 28 (Naval Observatory)	11	4		No spots				
Apr. 29 (Naval Observatory)	11	52		No spots				
Apr. 30 (Naval Observatory)	12	42		No spots				
Mean daily area for April								18

PROVISIONAL SUN-SPOT RELATIVE NUMBERS FOR APRIL 1933

(Dependent alone on observations at Zurich and its station at Arosa)

[Data furnished through the courtesy of Prof. W. Brunner, university of Zurich, Switzerland]

April 1933	Relative numbers	April 1933	Relative numbers	April 1933	Relative numbers
1	9	11	0	21	8
2	8	12	0	22	0
3	0	13	0	23	0
4	0	14	0	24	0
5	0	15	0	25	0
6	0	16	0	26	0
7	0	17	*Ec* 13	27	0
8	0	18	13	28	0
9	0	19	*a* 20	29	7
10	0	20	10	30	0

Mean: 30 days=2.9.

a=Passage of an average-sized or smaller group through the central meridian.
b=Passage of a large group or spot through the central meridian.
c=New formation of a center of activity: E, on the eastern part of the sun's disk; W, on the western part; M, in the central zone.
d=Entrance of a large or average-sized center of activity on the east limb.

AEROLOGICAL OBSERVATIONS

[Aerological Division, W. R. Gregg, in charge]

By L. T. SAMUELS

Free-air temperatures during April were close to the normals in practically all cases. (See table 1.) At most stations and levels the relative humidity departures were small and of opposite sign to those for temperature.

Resultant free-air wind directions were generally close to normal, except at the extreme northwestern stations where northerly components predominated. Resultant velocities were above normal, except over the north-central and northeastern sections where they were below normal. The greatest excess in resultant velocities occurred over the southeastern section of the country.

TABLE 1.—*Free-air temperatures and relative humidities during April 1933*

TEMPERATURE (° C.)

Altitude (meters) m.s.l.	Atlanta, Ga. (303 meters)[1]		Boston, Mass. (6 meters)[2]		Chicago, Ill. (187 meters)[3]		Cleveland, Ohio (246 meters)[3]		Dallas, Tex. (146 meters)[4]		Ellendale, N.Dak. (444 meters)		Norfolk, Va. (3 meters)[5]		Omaha, Nebr. (300 meters)[6]		Pensacola, Fla. (2 meters)[5]		San Diego, Calif. (9 meters)[5]		Washington, D.C. (2 meters)[5]	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Surface	11.0	(7)	7.7	+1.6	5.1	(7)	6.4	(7)	13.4	(7)	4.4	−1.2	12.4	+0.6	6.4	(7)	17.9	+0.1	15.6	−1.1	9.6	−1.6
500	11.9	(7)	3.5	−.8	5.5	(7)	7.2	(7)	15.8	(7)	4.1	−1.1	11.4	0	7.3	(7)	16.6	+.1	12.9	−.8	8.9	0
1,000	11.1	−0.3	2.0	+.2	5.3	−0.5	5.1	−0.7	15.1	+1.8	2.1	−.6	9.6	+.4	6.6	+1.0	14.7	+.2	10.3	−2.1	8.2	+1.4
1,500	8.7	+.1	.7	+1.3	4.1	+.6	2.7	−.8	13.3	+1.5	.4	−.1			4.7	+1.1						
2,000	6.2	+.4	−1.3	+1.2	1.4	+.2	0	−1.2	10.4	+.8	−2.0	+.1	5.0	+.5	2.3	+1.0	10.9	+.7	5.5	−3.2	3.4	−.3
2,500	3.6	+.2	−3.5	+1.0	−1.3	0	−2.1	−.8	7.7	+.8	−4.1	+.8			−.4	+.9						
3,000	.5	−.2	−5.8	+1.0	−3.9	−.1	−4.8	−1.0	4.5	+.6	−6.4	+1.5	−.2	+.3	−3.2	+.9	4.7	0	1.1	−1.9	−.7	−1.8
4,000	−6.1	−1.5	−11.2		−10.2	−1.2	−11.1	−2.1	−2.0	+.4	−11.5	+2.5			−10.0	+.2	−2.7	−.1	−4.8	−1.9	−6.0	−1.8
5,000	−13.4		−17.6		−17.5	−2.9	−18.0	−3.4	−9.0	−.8					−17.1	−1.0	−9.8	−.1				

RELATIVE HUMIDITY (PERCENT)

Altitude (meters) m.s.l.	Atlanta Mean	Atlanta Departure	Boston Mean	Boston Departure	Chicago Mean	Chicago Departure	Cleveland Mean	Cleveland Departure	Dallas Mean	Dallas Departure	Ellendale Mean	Ellendale Departure	Norfolk Mean	Norfolk Departure	Omaha Mean	Omaha Departure	Pensacola Mean	Pensacola Departure	San Diego Mean	San Diego Departure	Washington Mean	Washington Departure
Surface	85	(7)	70	0	82	(7)	76	(7)	72	(7)	64	−1	61	−3	72	(7)	80	+2	61	−6	70	+8
500	78	(7)	70	+6	76	(7)	67	(7)	60	(7)	64	0	55	0	67	(7)	72	+3	66	−7	65	+7
1,000	67	+7	67	0	68	+6	67	+5	48	−13	61	+1	51	+1	60	−2	68	+7	61	0	57	+2
1,500	65	+6	65	−3	66	+6	66	+6	40	−8	56	−1			54	−5						
2,000	62	+6	65	−2	62	+4	66	+8	36	−7	52	−3	42	−3	53	−4	56	+7	47	+8	54	0
2,500	58	+6	63	−5	60	+6	60	+6	36	−5	48	−6			55	−2						
3,000	57	+7	59	−9	54	+3	59	+8	37	−2	46	−8	39	−2	52	−4	52	+10	29	+2	50	+2
4,000	51	+3	54		46	−2	58	+10	41	−1	40	−16			47	−8	51	+9	22	+2	50	+3
5,000	48		51		42	−5	56	+9	38	0					46	−6	44	+9				

Weather Bureau airplane observations made near 5 a.m.; Navy airplane observations near 7 a.m.; Ellendale kite observations near 9 a.m. (75th meridian time).

[1] Temperature and humidity departures based on normals of Due West, S.C.

[2] Airplane observations made by Massachusetts Institute of Technology; departures based on normals obtained from kite observations made at Blue Hill Meteorological Observatory.

[3] Temperature and humidity departures based on normals of Royal Center, Ind.

[4] Temperature departures based on normals determined by interpolating between those of Groesbeck, Tex. and Broken Arrow, Okla. Humidity departures based on normals of Groesbeck, Tex.

[5] Naval air stations.

[6] Temperature and humidity departures based on normals of Drexel, Nebr.

[7] Surface and 500-meter level departures omitted because of difference in time of day between airplane observations and those of kites upon which the normals are based.

TABLE 2.—*Free-air resultant winds (meters per second) based on pilot-balloon observations made near 7 a.m. (E.S.T.) during April 1933*

[Wind from N=360°; E=90°, etc.]

Altitude (meters) m.s.l.	Albuquerque, N. Mex. (1,554 meters)		Atlanta, Ga. (309 meters)		Bismarck, N.Dak. (518 meters)		Brownsville, Tex. (12 meters)		Burlington, Vt. (132 meters)		Cheyenne, Wyo. (1,873 meters)		Chicago, Ill. (192 meters)		Cleveland, Ohio (245 meters)		Dallas, Tex. (154 meters)		Havre, Mont. (762 meters)		Jacksonville, Fla. (14 meters)		Key West, Fla. (11 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°	
Surface	289	1.9	240	0.3	45	0.9	135	1.5	155	1.6	299	5.4	329	0.3	162	1.8	164	1.3	257	0.2	305	1.0	128	1.8
500			267	.6			167	5.5	195	4.7			191	1.5	196	4.2	194	4.3			301	2.5	141	3.7
1,000			254	2.8	268	.7	186	3.1	248	4.0			242	3.4	232	5.2	238	6.3	265	1.7	275	4.1	183	2.1
1,500			278	4.5	284	3.4	199	3.0	276	5.0			253	3.7	246	5.7	259	6.4	279	2.3	268	6.1	235	2.6
2,000	287	4.0	276	7.3	294	4.2	217	3.4	284	8.2	299	8.1	293	4.9	251	5.1	277	7.2	282	4.7	274	7.6	249	3.8
2,500	290	5.9	256	9.3	308	8.0	256	3.9	298	9.4	306	10.5	307	5.4	262	6.8	284	8.0	288	5.3	278	8.7	265	4.2
3,000	281	6.7	261	11.2	303	9.7	254	4.6	279	4.6	308	8.6	329	4.8	271	7.8	288	9.2	305	4.7	278	11.1	291	4.7
4,000	269	10.3	260	12.6	295	10.7			280	4.6	299	10.1			283	9.8			327	9.7	282	12.7	294	8.9
5,000	268	12.4													292	11.4					274	13.2	303	14.6

Altitude (meters) m.s.l.	Los Angeles, Calif. (217 meters)		Medford, Oreg. (410 meters)		Memphis, Tenn. (83 meters)		New Orleans, La. (1 meter)		Oakland, Calif. (8 meters)		Oklahoma City, Okla. (402 meters)		Omaha, Nebr. (306 meters)		Phoenix, Ariz. (356 meters)		Salt Lake City, Utah (1,294 meters)		Sault Ste. Marie, Mich. (198 meters)		Seattle, Wash. (14 meters)		Washington, D.C. (10 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	°		°		°		°		°		°		°		°		°		°		°		°	
Surface	84	0.4	235	0.2	194	0.1	75	0.5	284	1.7	186	1.1	77	1.5	89	1.4	160	1.8	60	0.9	113	1.1	340	0.5
500	110	.7	309	.6	232	4.3	187	2.4	312	3.2	197	2.5	80	1.6	108	.3			60	2.1	287	.8	302	2.2
1,000	72	.4	322	1.1	257	6.0	263	3.4	353	4.6	244	5.8	314	1.3	271	1.6			18	1.6	340	1.7	297	5.1
1,500	324	1.4	33	1.0	268	7.4	268	5.6	332	3.6	269	6.9	310	4.2	244	1.9	169	3.0	321	3.4	313	1.7	281	7.1
2,000	314	2.3	359	2.0	278	8.7	264	5.7	318	3.9	259	7.0	294	5.5	240	2.3	194	2.4	309	6.1	310	2.3	272	7.6
2,500	333	4.2	332	4.2	286	10.1	270	8.5	330	4.0	272	7.7	299	8.1	232	3.9	272	2.2	305	6.7	323	3.1	274	10.2
3,000	344	4.1	317	4.8	281	10.1	272	12.2	326	5.5	274	9.6	290	8.7	240	4.2	299	3.2	301	7.5	322	5.9	275	10.5
4,000	321	7.6	323	6.3	283	11.6	271	16.2	319	7.9	269	14.7			254	7.6	310	5.6	287	7.1	327	6.0	273	10.0
5,000			322	7.9											262	8.2	322	9.0	255	4.8			259	11.1

RIVERS AND FLOODS

By MONTROSE W. HAYES

[In charge River and Flood Division]

During April 1933 there were minor floods in the rivers of Michigan, and in some of the rivers draining into the Atlantic Ocean and the Gulf of Mexico. In addition, there were important floods in rivers in Iowa, in the Illinois, Wabash and Ohio Rivers, and in the rivers in the lower Mississippi Basin. Some of the floods were continuations of the overflows of March, and others had not begun to recede at the end of April. Therefore, a discussion of the floods of both March and April will appear in a later issue of the REVIEW.

THE WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

[By the Marine Division, W. F. McDonald in charge]

NORTH ATLANTIC OCEAN

By W. F. McDONALD

Atmospheric pressure.—Average pressure during April 1933 was, for the third month in succession, below normal over mid-latitude portions of the Atlantic. The deficiency in April was not large, exceeding a tenth of an inch only at Horta, but pressures were below normal from the Azores far southwestward over the Caribbean Sea and Gulf of Mexico.

In higher latitudes, the barometer averaged higher than normal. The excess at Belle Isle approached a quarter of an inch, and was above a tenth of an inch eastward to the British Isles and thence south to Gibraltar.

The extreme range of pressure shown at land stations (see table 1) was from 29.06 to 30.54 inches; both of these extremes were reported from the same station, Halifax. Pressure readings reported from ships on the North Atlantic revealed almost identical range, from the highest reading, 30.53, reported by the American S.S. *American Merchant*, at 42°30′ N., 60°10′ W., on the 15th, to lowest, 29.06, reported by the American S.S. *City of Baltimore*, at 44°50′ N., 32°30′ W., on the 20th.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, April 1933*

Stations	Average pressure	Departure	Highest	Date	Lowest	Date
	In.	In.	In.		In.	
Julianehaab, Greenland	30.06	------	30.52	14	29.60	19
Reykjavik, Iceland	29.96	+0.16	30.50	19	29.15	2
Lerwick, Shetland Islands	29.94	+.14	30.47	14	29.46	3
Valencia, Ireland	30.05	+.16	30.45	14	29.47	25
Lisbon, Portugal	30.11	+.12	30.34	26	29.79	30
Madeira	30.09	+.08	30.52	1	29.79	29
Horta, Azores	30.01	−.14	30.33	1	29.63	23
Belle Isle, Newfoundland	30.06	+.23	30.42	12	29.42	24
Halifax, Nova Scotia	30.02	+.09	30.54	13	29.06	5
Nantucket	29.98	+.01	30.43	20	29.27	4
Hatteras	29.96	−.05	30.29	13	29.52	25
Bermuda	29.99	−.10	30.32	1	29.46	26
Turks Island	29.98	−.04	30.10	1	29.92	11, 21, 22, 29
Key West	29.95	−.07	30.12	1	29.78	25
New Orleans	29.91	−.09	30.23	12	29.63	5
Cape Gracias, Nicaragua	29.89	−.08	29.94	1, 2, 12	29.82	23

NOTE.—All data based on a.m. observations only, with departures compiled from best available normals related to time of observations, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—April opened with a well-developed cyclonic area central not far east of Cape Race. With this center of low pressure there merged during the next 10 days, a succession of cyclonic waves that passed into the Atlantic off the North American Continent. In the meantime, the original disturbance moved slowly northeastward toward Iceland.

These disturbances were not generally severe over a wide area, but were marked, especially during the first few days of the month, by squalls and thunderstorms of violent local character. Several vessels in the vicinity of Cape Hatteras on the 4th encountered and reported unusual line squalls, evidently connected with the frontal disturbance which destroyed the U.S. Navy dirigible *Akron* just off the coast of New Jersey, shortly after midnight of April 3–4.

Destruction of the *Akron* with 73 lives, was the only storm loss of serious proportions on the Atlantic during the month. The weather attending this disaster is of such great interest that charts VIII and IX, for April 3 and 4, 1933, are used to record the conditions on the morning preceding and following that event.

The low-pressure area shown on the New England coast in chart IX developed greater intensity as it moved on northeastward and caused fairly wide-spread gales on the 6th and 7th over the Atlantic west of the 35th meridian and southward in mid-ocean to the 35th parallel.

On the 14th a cyclonic development extending from the Azores to southern Greenland caused gales over the middle part of the main northern steamer routes. The period from the 7th to the 22d was otherwise relatively free from strong winds, although low pressure persisted steadily over the mid-Atlantic near the Azores.

The stormiest period of the month was the 3 days from the 23d to the 25th, when extensive cyclonic developments dominated the western and northern portions of the Atlantic. The highest wind recorded during the month was force 11, encountered by the American S.S. *American Farmer* near latitude 41° N., longitude 19° W., on the 24th.

High pressure conditions overspread the Atlantic after the 26th, and the last 4 days were practically free from winds of gale force.

Fog.—Fogginess increased greatly on the American coast from Cape Hatteras to the Grand Banks, where this condition was reported on 7 to 13 days. The highest frequency was between Cape Cod and Cape Hatteras. There were a few days with fog over mid-ocean, and a maximum of 5 days on the approaches to the English Channel.

OCEAN GALES AND STORMS, APRIL 1933

Vessel	Voyage: From—	Voyage: To—	Position at time of lowest barometer: Latitude	Position at time of lowest barometer: Longitude	Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
NORTH ATLANTIC OCEAN			° ′	° ′				Inches					
Livenza, Ital.S.S.	Gibraltar	New York	38 20 N	64 16 W	Apr. 1	Noon, 2.	Apr. 2	29.76	WSW	SW, 8	SW	SW, 8	Steady.
Japan Arrow, Am.S.S.	New York	Sabine	33 10 N	75 45 W	Apr. 4	2 a., 4.	Apr. 4	29.60	SW	SW, 7	NW	W, 8	SW-WSW.
Atlantic Sun, Am.S.S.	Houston	Marcus Hook	33 00 N	76 50 W	do	1 a, 4.	do		SW	— 6	NW	—, 10	SW-W-NW.
Europa, Ger.S.S.	New York	English Channel.	42 03 N	61 40 W	Apr. 5	4 p., 5.	Apr. 5	29.58	WSW	W, 8	NW	WSW, 9	
President Adams, Am. S.S.	Gibraltar	New York	42 14 N	32 32 W	Apr. 4	4 a, 5.	do	29.51	W	NW, 6		NW, 8	
Black Tern, Am.S.S.	New York	Rotterdam	41 08 N	48 27 W	do	Mdt., 6.	Apr. 7	29.36	WSW	N, 6	NNW	W, 9	NW-N.
Maasdam, Du.S.S.	Antwerp	Habana	33 49 N	48 03 W	Apr. 6	4 a., 7.	do	29.62	W	W, 9	WNW	WNW, 9	W-WNW.
Exmouth, Am.S.S.	Casablanca	Norfolk	35 31 N	39 10 W	Apr. 7	2 p., 7.	do	29.50	S	SW, 7	W	WSW, 8	
Scanpenn, Am.S.S.	Copenhagen	New York	58 33 N	9 00 W	Apr. 12	2 a., 12.	Apr. 12	29.79	W	W, 7	NW	WNW, 8	W-NW.
Penrith Castle, Br. S.S.	Gibraltar	do	37 52 N	40 25 W	do	4 p., 13.	Apr. 15	29.90	S	W, 6	NW	NW, 8	Steady.
Silverwalnut, Br.M.S.	Port Said	Boston	40 10 N	38 20 W	Apr. 13	2 p., 14.	do	29.59	SW	WNW, 8	N	NNW, 9	WSW-WNW.
Youngstown, Am.S.S.	Rotterdam	Tampico	23 00 N	94 40 W	Apr. 15	—, 15.	do	29.99	NNW	NNW, —	NNW	N, 8	
Capetown Maru, Jap. S.S.	Hamburg	New York	45 28 N	35 20 W	Apr. 16	10 a., 16.	Apr. 17	29.25	W	NW, 9	NW	NW, 9	
W. S. Miller, Am.S.S.	Houston	Fall River	39 34 N	71 57 W	Apr. 19	10 a., 19.	Apr. 24	30.06	NE	NE, —	NE	NE, 8	Steady.
West Imboden, Am.S.S.	Pernambuco	Boston	35 27 N	62 21 W	Apr. 17	4 p., 20.	Apr. 21	29.93	NE	NE, 8	NE	NE, 8	Do.
Coamo, Am.S.S.	New York	San Juan and return.	34 20 N	71 30 W	Apr. 23	2 a., 23.	Apr. 23	29.67	N	N, 8	N	NE, 8	N-NE-N.
West Madaket, Am.S.S.	Avonmouth	Panama City, Fla.	44 00 N	23 15 W	do	10 p., 23.	Apr. 24	29.20	SSW	SW, 8	NW	NW, 10	SSW-NW.
Binnendyk, Du.S.S.	Habana	Antwerp	37 35 N	52 38 W	do	4 a., 24.	do	29.40	SSE	S, 8	NNW	S, 8	SSE-S-NW.
Black Gull, Am.S.S.	New York	do	44 50 N	42 26 W	Apr. 24	6 p., 24.	do	29.50	S	S, 8	NW	NW, 9	
American Farmer, Am. S.S.	London	New York	41 03 N	18 45 W	Apr. 23	10 a., 24.	Apr. 25	28.95	SSW	W, 10	WSW	W, 11	
Tuscarora, Br.S.S.	do	Philadelphia	49 32 N	15 54 W	Apr. 22	10 —, 24.	Apr. 26	29.17	SW	S, 9	WNW	SW, 10	S-SW-W.
Mexican, Am.S.S.	Wilmington, Calif.	New York	35 30 N	73 32 W	Apr. 25		Apr. 25	29.47	SSW		WSW	SSW, 10	Steady.
Black Tern, Am.S.S.	Antwerp	Baltimore	49 44 N	14 20 W	do	8 a, 25.	Apr. 27	29.48	SSE	WSW, 7	N	W, 9	SSE-SW-W.
McKeesport, Am.S.S.	Havre	New York	41 18 N	64 30 W	Apr. 26	9 a, 26.	Apr. 26	29.44	S	S, 9	SW	S, 9	S-SSW.
Black Falcon, Am.S.S.	New York	Rotterdam	49 11 N	21 55 W	Apr. 28	8 p., 30.	Apr. 30	29.89	N	NNE, 7	NNE	NNE, 9	N-NNE.
NORTH PACIFIC OCEAN													
Yeiyo Maru, Jap.S.S.	Yokohama	Los Angeles	42 30 N	166 10 E	Mar. 31	8 p., 1.	Apr. 3	29.04	SW	S, 5	W	W, 8	S-W.
Hauraki, Br.M.S.	Suva, Fiji	Vancouver	48 20 N	125 05 W	Apr. 2	8 p., 3.	do	30.13	WNW	NW, 7	NW	NW, 8	WNW-NW.
City of Victoria, Br.S.S.	Muroran	do	47 40 N	160 59 E	do	8 a., 2.	do	28.87	W	W, 7	NW	NW, 8	Steady.
Batoe, Du.S.S.	Los Angeles	Portland	40 53 N	124 51 W	Apr. 3	—, 4.	Apr. 4	29.88	NNW	NNW, 11	N	NNW, 11	N-NNW-N.
Admiral Peoples, Am. S.S.	Portland	San Diego	44 49 N	124 18 W	Apr. 5	4 p., 5.	Apr. 7	29.79	N	NNW, —	N	NNW, 8	Steady.
Silverbelle, Br.M.S.	Manila	Portland	49 57 N	164 45 W	Apr. 8	—, 9.	Apr. 10	29.45	NNW	W, 8	NW	W, 8	Do.
City of Victoria, Br.S.S.	Muroran	Vancouver	49 02 N	144 00 W	Apr. 12	4 a., 12.	Apr. 13	29.41	SSW	SSW, 7	SW	SSW, 8	Do.
New York, Am.S.S.	Otaru	San Francisco.	42 17 N	146 50 E	Apr. 15	5 a., 16.	Apr. 16	29.12	S		S	S, 8	SSW-SW.
Levant Arrow, Am.S.S.	Dairen	San Pedro	39 35 N	153 45 E	do	10 a., 16.	Apr. 17	29.47	SE	S, 9	W	S, 9	SSE-S-W.
New York, Am.S.S.	Otaru	San Francisco.	49 39 N	163 30 W	Apr. 23	7 a., 24.	Apr. 25	29.02	ESE			S, 9	Steady.
Kiyo Maru, Jap.S.S.	Yokohama	Los Angeles	41 36 N	164 21 E	do	2 p., 23.	do	29.09	NE	NE, 8	NW	NE, 8	E-NE-N.
Bonneville, Nor.M.S.	Bais, P.I.	San Pedro	39 29 N	179 28 E	do	10 a., 24.	do	29.42	SSE	SW, 11	WNW	WSW, 11	SW-WSW.
Olympia, Am.S.S.	Taku Bar	Vancouver	49 35 N	163 35 W	Apr. 27		Apr. 28	29.58	S		SSW	S, 10	Steady.
Stanley Dollar, Am.S.S.	Guam	Los Angeles	40 20 N	173 30 E	Apr. 28	10 a., 28.	do	29.49	WSW	WSW, —	WSW	WSW, 9	Do.
Ethan Allen, Am.S.S.	Cebu, P.I.	San Pedro	32 00 N	155 00 E	do	3 a., 29.	Apr. 29	29.78	NE	ENE, 9	NE	ENE, 9	E-ENE-NE.
Bonneville, Nor.M.S.	Bais	do	40 35 N	144 50 W	Apr. 29	1 a., 30.	May 1	29.84	SW	WSW, 7	NW	WNW, 9	WSW-W.
SOUTH PAFIFIC OCEAN													
Elveric, Br.S.S.	Tyne	Melbourne	41 04 S	129 50 E	Apr. 7	2 p,. 10.	Apr. 13	[1] 29.38	NNE	NW, 4	SW	NNW, 10.	
Monterey, Am.S.S.	Pago Pago	San Pedro	31 00 S	175 49 E	Apr. 11	4 p., 12.	do	29.34	ESE	ESE, 9	NW	ESE, 9	E-ESE-NE.

[1] Barometer uncorrected.

NORTH PACIFIC OCEAN, APRIL 1933

By WILLIS E. HURD

Atmospheric pressure.—During April 1933 the greater part of the centers of cyclonic action on the North Pacific except in the northwestern sector, ran in higher latitudes than normal, and as a consequence the average center of the Aleutian LOW lay over the Bering Sea (St. Paul, 29.67 inches), where the pressure was a tenth of an inch below the normal.

Anticyclonic conditions were well established over most of the middle-latitude region and the extreme northeast, with pressures above normal from lower Alaska and the northern west coast of the United States southwestward to Midway Island and thence westward to the China coast. Depressions were few or entirely absent over much of the eastern half of this great area during the month.

Cyclones and gales.—A sharp diminution in gale occurrence was experienced in April as compared with March on the North Pacific. Even in the neighborhood of the Kuril Islands and northern Japan—frequently the stormiest region of the ocean—gales were infrequent, with none reported as exceeding force 9.

Cyclonic activity was for the most part comparatively weak over the main ocean routes, except during the periods of considerably depressed barometer which occurred over the Aleutian area on a few early and late days of the month. The second of these periods caused the most wide-spread storminess of April, during the 23d to 28th. The area swept spottedly by gales at this time lay roughly between latitude 39° N. and the Aleutian Islands and longitudes 160° W. and 170° E. Few observations, however, showed winds exceeding 9 in force, and of these the severest was a southwesterly gale of force 11 near the one hundred and eightieth meridian and 40° N. on the 24th.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, April 1933, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Point Barrow	29.99	−0.10	30.30	16	29.62	30
Dutch Harbor	29.72	−.06	30.48	16	28.64	25
St. Paul	29.67	−.12	30.52	16	28.60	2
Kodiak	29.79	+.04	30.34	7	29.16	29
Juneau	30.02	+.06	30.40	3	29.58	30
Tatoosh Island	30.11	+.11	30.47	1	29.65	29
San Francisco	30.00	−.05	30.26	10	29.68	4
Mazatlan	29.88	−.08	29.98	28	29.78	4
Honolulu	30.05	−.01	30.15	29	29.86	9
Midway Island	30.15	+.03	30.32	2, 26	29.92	11
Guam	29.88	−.01	29.94	12, 14, 24	29.82	8, 21, 22
Manila	29.86	−.04	29.92	12, 15, 29	29.80	20, 22
Naha	29.96	+.04	30.14	1	29.80	25
Chichishima	30.03	+.06	30.22	2	29.72	27
Nemuro	30.02	--------	30.42	3	29.24	15

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observation.

Local gales occurred along the American coast near Capes Flattery and Mendocino on the 3d, and at the latter point continued into the 4th, attaining a force of 11 from north-northwest during the night. Northerly gales also occurred near Cape Mendocino on the 5th and 6th. According to press reports the Grays Harbor (Wash.) fishing fleet was badly hit by the blow on the afternoon of the 5th. Ten boats and 15 men were officially declared lost, and an additional 4 boats and 4 men were still missing on the 8th.

Gales and storms in the Tropics.—Mostly quiet weather prevailed in tropical latitudes. In the Gulf of Tehuantepec, however, a moderate norther was experienced on the 15th.

In the Far East, as shown on the Japanese weather maps, a tropical disturbance of apparently moderate intensity appeared on the 22d as a slight depression between Guam and Yap. It moved westward for some distance toward the Philippine Islands, then recurved into north and northeast, passing south of the Ogasawara Islands on the 27th, from between which point and southern Japan the S.S. *Hide Maru* reported a strong gale to the Tokyo office. The American steamer *Ethan Allen* reported receiving a warning from the Tokyo Central Observatory that the typhoon was central in 31° N., 152° E., moving northeast, on the 28th. The ship was in a moderate gale in the vicinity on that date, and in a strong gale early on the 29th in 32° N., 155° E.

Fog.—Scattered fogs were encountered on both northern and middle steamer routes from coast to coast at intervals throughout the month. It was most widespread on the 1st and 2d, at which time it blanketed much of the region east of 150° W., between parallels 40° and 50° N. Fog was noted on 6 days off the California coast, and on 5 days off the Mexican coast between Salina Cruz and Cape Corrientes. The observer on the American steamer *San Vincente*, Second Officer Hamrick, called special attention to the extraordinary frequency of fog "so far south on the west coast of Mexico." Much of the fog here was very wet and formed over a comparatively cold oceanic current from the southeast.

HURRICANE IN THE SOUTH PACIFIC OCEAN, MARCH 1933

According to a report from the American motorship *Jeff Davis*, Balboa to Brisbane, Captain N. Leknes, observer, J. W. Engh, a hurricane occurred on March 29–30, 1933, a little south of midway between the Cook and Tonga Islands. The ship experienced frequent squalls of force 12 "and over" from noon to midnight of the 29th. Her lowest barometer was 29.37 inches at 7 p.m. of the 29th in 23°40′ S., 168°30′ W. — *W. E. H.*

CLIMATOLOGICAL TABLES

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, April 1933

[Compiled by Annie E. Small]

[For description of tables and charts, see REVIEW, January, p. 37]

Section	Temperature: Section average	Temperature: Departure from the normal	Monthly extremes: Station	Highest	Date	Station	Lowest	Date	Precipitation: Section average	Departure from the normal	Greatest monthly: Station	Amount	Least monthly: Station	Amount
	° F.	° F.		° F.			° F.		In.	In.		In.		In.
Alabama	62.7	−1.1	Thomasville	90	29	St. Bernard	31	4	6.50	+2.23	Seven Hills	14.35	Auburn	2.27
Arizona	56.0	−4.1	2 stations	98	[1] 3	Williams	8	15	.81	+.13	Ashdale Ranger Station.	3.51	4 stations	.00
Arkansas	61.1	−.4	Dardanelle	93	10	Mount Ida	28	12	4.80	−.13	Corning	9.14	Subiaco	2.27
California	54.0	−2.2	3 stations	100	3	Ellery Lake	−10	18	.62	−.97	Cuyamaca	6.61	20 stations	.00
Colorado	40.9	−2.6	Holly	87	18	Dillon	−23	14	2.49	+.69	Westcliffe	8.34	Manassa	.13
Florida	70.3	+.4	2 stations	94	10	Garniers (near)	38	[1] 4	7.13	+4.34	Blountstown	17.56	Key West	.59
Georgia	62.7	−.8	Millen	89	19	Clayton	29	13	4.09	+.51	Bainbridge	8.98	Augusta	1.01
Idaho	42.7	−2.2	Glenns Ferry	86	23	Blackfoot Dam	−12	11	.84	−.52	Bungalow Ranger Station.	3.34	Mud Lake	.00
Illinois	52.0	−.2	Hardin	89	9	Ottawa	21	27	3.55	+.12	Chester	6.63	Aledo	1.66
Indiana	51.8	−.1	Bedford	86	30	5 stations	25	[1] 8	4.52	+.97	Marengo	7.60	Salamonia	2.64
Iowa	48.8	+.1	Keokuk No. 2	85	28	Washta	16	14	1.21	−1.56	Columbus Junction	3.08	Logan	.33
Kansas	54.7	.0	Ashland	93	18	St. Francis	11	6	2.42	−.23	Coffeyville	5.87	Hesston	.07
Kentucky	55.7	−.4	Pippapass	87	10	Williamstown	27	23	4.74	+.75	Murray	6.92	Eubank	2.65
Louisiana	67.2	+1.1	2 stations	93	28	2 stations	35	7	7.00	+2.35	Bogalusa	14.25	Lake Charles	2.71
Maryland-Delaware	52.8	+.4	do	88	29	Oakland, Md	20	13	5.44	+1.87	Baltimore, Md	7.58	Pocomoke City, Md	3.61
Michigan	43.0	+.4	Adrian	82	29	Wolverine	9	22	3.31	+.74	Eau Claire	5.50	Muskegon	1.23
Minnesota	41.6	−1.7	2 stations	81	29	Redby	7	7	1.59	−.48	Pigeon River Bridge	4.85	Artichoke Lake	.60
Mississippi	63.9	−.7	Greenwood	92	30	4 stations	35	[1] 7	7.82	+2.95	Brookhaven	16.57	Fulton	3.10
Missouri	54.9	−.3	Louisiana	90	28	Goodland	22	7	3.53	−.39	2 stations	7.85	Grant City	.71
Montana	40.5	−2.4	Libby	80	25	2 stations	−5	10	1.50	+.34	Mystic Lake	3.66	Hamilton	.35
Nebraska	48.8	−.2	3 stations	86	[1] 7	Box Butte Expt. Farm.	8	7	2.86	+.41	Gosper	8.82	Tekamah	.32
Nevada	47.0	−.6	Logandale	93	3	Zorra Vista Ranch	−1	10	.59	−.17	Lamoille	2.83	Mina	.00
New England	43.7	.0	Stockbridge, Mass	85	29	Pittsburg, N.H	10	23	5.81	+2.52	Durham, N.H	12.49	Jackman, Me	3.07
New Jersey	50.4	+.7	2 stations	85	[1] 29	2 stations	20	[1] 23	4.84	+1.23	Little Falls	7.09	Tuckerton	3.52
New Mexico	47.7	−3.7	Fort Sumner	92	7	3 stations	−12	14	.40	−.58	Penasco	2.40	8 stations	.00
New York	46.4	+2.1	Dansville	86	30	Gabriels	10	23	3.97	+1.01	Mohawk Lake	7.41	South Wales	1.63
North Carolina	57.9	.0	Fayetteville	89	10	Mount Mitchell	18	7	4.01	+.51	Boone	8.90	Albemarle	1.84
North Dakota	40.0	−1.6	McLeod	84	18	Willow City	2	11	1.33	−.06	Power	2.90	Maddock	.13
Ohio	50.9	+1.0	3 stations	87	[1] 10	2 stations	23	23	3.74	+.58	Wilmington	6.47	Kenton	1.85
Oklahoma	61.0	+.6	Hollis	94	17	Goodwell	18	11	3.05	−.40	Watts	8.75	Altus	.25
Oregon	46.0	−1.0	Umatilla	90	27	Sand Creek	4	9	1.13	−.84	Meacham	3.76	4 stations	T.
Pennsylvania	50.9	+2.2	Hyndman	89	29	2 stations	15	[1] 22	4.49	+1.05	Hamburg	6.20	Warren	2.19
South Carolina	61.1	−1.2	4 stations	87	[1] 2	do	30	[1] 4	2.31	−.73	2 stations	5.85	Columbia	.80
South Dakota	45.6	−.4	Cedar View	88	18	McLaughlin	8	11	1.67	−.50	Harveys Ranch	5.83	Arlington	.22
Tennessee	58.2	−.5	Loudon	88	30	Ashwood	15	3	4.17	−.30	Union City	7.96	McGhee	2.49
Texas	66.4	+.2	Hebbronville	106	29	Vega	17	14	1.36	−1.80	Wiergate	8.82	13 stations	.00
Utah	43.4	−3.5	2 stations	85	[1] 3	Soldiers Summit	−4	10	1.29	+.10	Silver Lake	4.02	Castle Dale	T.
Virginia	55.0	+.5	Clarksville	90	29	Woodstock	23	23	4.44	+1.18	Afton	7.71	Cape Henry	2.07
Washington	47.2	−.6	Prosser	92	26	Spirit Lake	6	10	.98	−1.42	Palmer	4.21	Hanford	.00
West Virginia	52.8	+1.0	Charleston	91	30	Bayard	19	22	4.08	+.55	Pickens	6.34	Hinton	2.44
Wisconsin	41.9	−1.9	2 stations	81	29	2 stations	6	14	2.73	+.17	Arlington	4.39	Oconto	1.14
Wyoming	37.1	−3.0	3 stations	79	16	do	−17	[1] 10	2.29	+.71	Dome Lake	7.05	Tower Falls	.19
Alaska (March)	13.2	−.4	Tree Point	57	24	Allakaket	−46	1	1.32	−.65	View Cove	13.90	McKinley Park	.00
Hawaii	69.6	−.8	Kaanapali	89	27	Kanalohuluhulu	40	[1] 4	5.19	−3.41	Piihonua	24.42	Halawa	.16
Puerto Rico	75.5	+.1	Bayamon	96	26	Guineo Reservoir	43	19	3.75	−.94	Guineo Reservoir	9.17	Arecibo	.37

[1] Other dates also.

TABLE 1.—*Climatological data for Weather Bureau stations, April 1933*

[Compiled by Annie E. Small]

District and station	Elevation of instruments: Barometer above sea level	Thermometer above ground	Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Departure from normal	Days with 0.01, or more	Wind: Total movement	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England							44.3	+0.4										78	5.47	+2.4										6.6		
Eastport	76	67	85	29.92	30.01	+0.08	39.6	+0.6	60	24	45	22	23	34	24	37	34	84	3.29	+0.4	15	8,349	sw.	35	e.	4	5	7	18	7.4	0.7	0.0
Greenville, Me	1,070	6		28.81	30.00		38.0		67	30	46	17	23	29	30				4.28		17	5,381	se.	34		5	4	6	20		17.2	
Portland, Me	103	82	117	29.88	30.00	+.04	42.8	−.2	73	24	49	27	23	37	33	38	33	72	9.35	+6.0	19	7,149	e.	35	nw.	5	8	9	13	6.0	11.7	.0
Concord	289	70	79	29.67	29.99	.00	43.0	−.4	72	29	52	25	23	34	38				6.36	+3.6	16	4,863	w.	26	nw.	5	12	6	12	5.8	18.3	.0
Burlington	403	11	48	29.53	29.98	−.01	43.8	+.5	79	30	52	24	23	36	38				3.89	+1.7	17	7,429	se.	34	se.	11	5	7	18	7.4	.8	.0
Northfield	876	12	60		30.01	+.02	41.0	+.7	77	30	50	21	23	32	44			82	4.89	+2.6	16	5,828	s.	22	n.	5	2	13	15	7.1	14.0	.0
Boston	125	106	165	29.86	30.00	+.03	46.5	+.1	76	29	53	29	23	40	31	41	36	72	7.37	+4.0	14	7,056	e.	32	n.	13	7	9	14	6.5	5.0	.0
Nantucket	12	14	90	29.97	29.98	+.01	45.5	+2.1	64	30	51	32	21	40	21	42	39	83	4.78	+1.8	12	12,324	s.	43	ne.	19	8	4	18	6.2	.0	.0
Block Island	26	11	46	29.95	29.98	.00	44.4	+.4	64	30	49	32	23	40	17	42	40	88	5.56	+2.0	14	12,487	w.	47	n.	13	8	7	15	6.3	.0	.0
Providence	160	215	251	29.82	29.99	+.01	46.4	−.2	76	30	54	28	23	39	29	41	35	69	5.33	+2.1	14	8,896	nw.	40	nw.	5	8	7	15	6.2	.6	.0
Hartford	159	122		29.83	30.01	+.02	47.4	+.7	74	30	56	30	23	39	33				4.69	+1.3	17		n.				5	10	15	6.8	1.0	.0
New Haven	106	74	153	29.89	30.00	+.01	47.4	+.2	70	24	55	30	23	40	29	43	40	78	4.64	+1.1	18	7,301	n.	32	ne.	13	6	8	16	7.1	T.	.0
Middle Atlantic States							52.9	+1.3										68	4.16	+1.1										5.8		
Albany	97	107	115	29.89	30.00	.00	48.6	+1.8	79	30	57	29	23	40	36	42	35	65	3.92	+1.5	13	5,772	s.	23	se.	29	7	9	14	6.5	2.7	.0
Binghamton	871	60	68	29.04	29.98	−.04	48.6	+3.2	79	30	58	25	23	39	36				3.27	+.8	14	4,910	nw.	24	sw.	29	6	3	21	7.8	.8	.0
New York	314	414	454	29.64	29.98	−.02	50.1	+.7	76	29	58	32	12	42	28	44	38	69	4.49	+1.3	11	9,844	se.	46	nw.	4	6	9	15	6.6	T.	.0
Bellefonte	1,050	5	42	28.84	29.95		48.4		78	29	60	23	23	37	38	43	37	68	4.53		15		se.				7	8	15	6.7	T.	.0
Harrisburg	374	94	104	29.56	29.97	−.05	52.3	+1.4	81	29	62	33	23	43	31	45	38	62	5.17	+2.5	14	6,173	e.	24	nw.	26	11	12	7	5.1	.0	.0
Philadelphia	114	123	367	29.87	30.00	−.01	53.8	+1.7	79	29	62	34	23	45	27	46	39	63	5.26	+2.2	11	10,290	sw.	36	e.	19	9	10	11	5.6	.0	.0
Reading	323	283	304	29.63	29.98		52.6	+2.3	82	29	62	30	23	43	34	45	38	63	4.14	+.9	12	10,286	se.	38	e.	19	8	13	9	5.7	.3	.0
Scranton	805	72	103	29.10	29.97	−.04	49.9	+1.8	79	29	60	26	23	40	37	43	36	62	3.73	+1.0	11	5,248	nw.	23	se.	11	7	12	11	6.0	4.0	.0
Atlantic City	52	37	172	29.93	29.99	−.01	49.3	+1.5	67	2	55	33	23	43	24	45	41	80	3.79	+.8	12	13,406	s.	49	ne.	20	9	8	13	6.2	.0	.0
Sandy Hook	22	10	55	29.96	29.98		48.2		73	29	54	35	23	42	24	44	41	79	4.46	+.8	12	10,503	e.	35	n.	12	7	10	13	6.1	T.	.0
Trenton	190	159	183	29.78	29.99		51.0	+1.2	80	29	60	31	23	42	32	45	40	71	4.40	+1.5	12	7,560	s.	32	w.	26	8	9	13	6.0	T.	.0
Baltimore	123	100	215	29.85	29.98	−.03	54.7	+1.1	76	29	63	34	23	46	33	47	41	65	7.58	+4.2	12	8,570	se.	32	se.	28	11	9	10	5.4	T.	.0
Washington	112	62	85	29.85	29.97	−.05	55.7	+2.4	83	29	66	33	23	46	38	47	39	60	4.67	+1.4	12	5,948	s.	25	nw.	4	13	11	6	4.7	.0	.0
Cape Henry	18	8	54	29.94	29.96		55.5	+.9	78	6	62	39	5	49	31	51	48	77	2.07	−1.2	8	9,654	se.	48	ne.	20	12	6	12	5.3	.0	.0
Lynchburg	681	153	188	29.21	29.95	−.07	56.4	−.9	83	10	68	35	13	45	36	50	45	70	4.41	+1.5	13	5,474	w.	29	nw.	3	13	9	8	4.8	.0	.0
Norfolk	91	170	205	29.88	29.98	−.03	58.6	+1.8	78	10	67	41	23	50	33	51	47	73	2.13	−1.1	12	9,539	ne.	39	nw.	3	11	8	11	5.8	.0	.0
Richmond	144	11	52	29.82	29.97	−.05	56.8	+.2	80	9	68	35	23	46	37	50	44	69	4.02	+.5	12	6,671	ne.	27	n.	12	13	8	9	4.8	.0	.0
Wytheville	2,304	49	55	27.57	29.95	−.08	51.8	−.2	78	10	62	29	13	41	36	44	38	66	3.34	+.4	11	5,682	w.	27	w.	2	10	11	9	5.5	.0	.0
South Atlantic States							62.0	+0.2										69	3.30	+0.3										5.4		
Asheville	2,253	89	104	27.60	29.94	−.09	54.8	+.9	81	10	67	32	13	43	38	47	41	67	2.59	−.4	11	7,089	se.	30	s.	3	8	14	8	5.4	.0	.0
Charlotte	779	244	267	29.13	29.97	−.06	59.8	.0	82	10	69	38	21	50	25	51	43	62	2.02	−1.3	10	9,238	w.	32	sw.	3	11	8	11	5.1	.0	.0
Greensboro	886	6	56	29.01	29.97		56.3		84	10	69	34	13	44	30	49	44	69	2.95		12	6,647	sw.	31	sw.	3	11	5	14	5.3	.0	.0
Hatteras	11	5	50	29.94	29.95	−.06	61.2	+1.4	77	10	67	42	24	55	24	58	55	80	4.72	+1.2	11	9,860	sw.	38	n.	12	12	10	8	4.8	.0	.0
Raleigh	376	103	146	29.55	29.95	−.08	60.0	+.6	84	10	71	39	21	49	31	51	44	60	5.33	+1.9	12	7,239	sw.	31	w.	6	8	17	5	5.4	.0	.0
Wilmington	72	73	106	29.89	29.96	−.07	62.6	+.6	79	10	71	44	13	54	27	56	52	74	4.50	+1.8	9	7,894	sw.	38	nw.	4	11	11	8	5.2	.0	.0
Charleston	48	11	92	29.92	29.97	−.06	64.5	.0	83	26	72	49	22	58	24	58	54	73	2.29	−.2	11	8,565	sw.	32	n.	12	8	8	14	6.1	.0	.0
Columbia, S.C.	351	41	57	25.58	29.96	−.07	63.0	−.3	83	6	73	45	21	52	34	54	47	62	.80	−2.1	7	5,890	sw.	30	sw	3	11	10	9	5.1	.0	.0
Greenville, S. C.	1,039	139	146	28.85	29.95		59.4	+.8	81	10	69	42	4	50	29	51	44	63	3.72	.0	12	7,386	sw.	38	w.	18	13	6	11	4.8	.0	.0
Augusta	182	62	77	29.76	29.95	−.08	63.9	−.3	84	19	75	46	4	53	34	55	49	62	1.01	−2.1	5	5,150	se.	27	nw.	3	9	10	11	5.4	.0	.0
Savannah	65	73	152	29.90	29.97	−.06	65.7	−.3	84	19	75	47	22	57	29	59	55	77	2.12	−.4	12	8,075	sw.	30	nw.	3	9	6	15	6.2	.0	.0
Jacksonville	43	209	245	29.92	29.97	−.07	67.4	−1.3	81	19	74	54	4	60	21	60	56	74	7.16	+4.8	12	8,204	sw.	44	s.	1	8	9	13	6.1	.0	.0
Florida Peninsula							75.5	+2.3										76	3.81	+1.7										4.8		
Key West	22	10	64	29.93	29.95	−.07	78.6	+2.9	80	11	84	69	26	73	16	72	70	77	.59	−.7	5	6,400	se.	35	nw.	3	21	4	5	3.6	0.0	0.0
Miami	25	124	168	29.95	29.98	−.05	75.6	+2.8	90	28	82	62	26	69	22	69	66	75	4.71	+1.6	7	7,392	se.	26	se.	16	7	12	11	6.1	.0	.0
Tampa	35	88	197	29.93	29.97	−.09	72.2	+1.3	86	28	81	58	16	64	26	65	62	76	6.14	+4.1	11	7,724	e.	37	sw.	15	9	10	11	5.3	.0	.0
Titusville	44	5		29.91	29.96		70.9		88	27	79	53	8	62	27				6.28		9		w.				15	10	5	4.3	.0	.0
East Gulf States							64.3	−.4										75	6.49	+2.3										5.7		
Atlanta	1,173	190	198	28.72	29.96	−.07	59.6	−1.4	79	10	69	41	4	50	30	52	46	67	2.47	−1.1	10	7,846	w.	37	se.	15	12	7	11	5.4	.0	.0
Macon	370	76	84	29.56	29.96	−.07	63.0	−.9	82	30	74	44	4	52	34	55	49	69	2.42	−.7	13	5,462	sw.	25	nw.	7	10	9	11	5.5	.0	.0
Thomasville	273	49	103	29.66	29.96	−.07	66.0	−.7	87	30	75	47	4	57	34	60	56	77	8.18	+4.8	14	6,053	sw.	37	se.	15	9	7	14	6.2	.0	.0
Apalachicola	36	11	51	29.91	29.95		67.8		81	25	74	53	7	62	18	63	60	80	10.98	+8.2	11	6,841	se.	48	se.	14	11	10	9	5.1	.0	.0
Pensacola	56	149	185	29.88	29.94	−.08	66.9	+.2	80	3	72	50	12	61	20	63	62	87	7.86	+3.8	12	9,411	se.	54	se.	14	11	9	10	5.1	.0	.0
Anniston	741	9	57				61.2	+.8	83	19	73	35	4	50	37				4.55	+.2	15		se.				5	13	12		.0	.0
Birmingham	700	11	48	29.17	29.93	−.09	61.6	−1.7	83	29	72	39	4	52	32	54	50	72	2.86	−2.0	15	5,598	se.	28	se.	14	8	11	11	5.8	.0	.0
Mobile	57	125	161	29.87	29.93	−.09	66.8	+.5	83	25	74	48	16	59	25	61	57	79	14.12	+9.5	14	7,043	s.	34	se.	14	7	12	11	5.8	.0	.0
Montgomery	223	100	112	29.69	29.94	−.09	64.2	−1.1	84	29	73	45	4	55	26	57	52	70	5.72	+1.4	10	5,427	se.	24	se.	14	8	8	14	6.2	.0	.0
Corinth	469	6					62.6		88	10	74	36	12	51	37				7.42		14		se.				5	21	4		.0	.0
Meridian	375	87	95	29.52	29.91	−.11	63.8	−.2	84	29	74	39	7	54	36	57	52	73	5.46	+.7	12	4,526	se.	30	se.	14	7	10	13	5.9	.0	.0
Vicksburg	247	65	73	29.64	29.90	−.10	64.4	−1.2	86	30	73	40	15	55	31	58	54	75	6.87	+1.7	14	5,858	se.	30	w.	11	9	7	14	5.9	.0	.0
New Orleans	53	76	84	29.86	29.91	−.09	70.0	+1.2	90	28	77	46	15	62	22	63	59	75	6.38	+1.1	11	5,447	se.	21	sw.	15	9	13	8	5.3	.0	.0
West Gulf States							67.4	+0.9										68	2.19	−1.4										5.0		
Shreveport	249	92	227	29.61	29.88	−.00	65.9	+.1	91	30	76	39	15	56	34	58	53	70	5.19	+.6	12	8,532	s.	40	s.	4	10	8	12	5.5	T.	.0
Bentonville	1,303	11	44	28.47	29.83	−.13	56.8	−.1	85	9	68	32	14	46	33				6.93		10	5,522	nw.	24	se.	4	12	9	9		12.0	.0
Fort Smith	457	79	94	29.37	29.85	−.11	61.7	−.1	89	9	73	33	15	50	35	52	46	64	3.98	.0	9	6,503	nw.	29	se.	29	11	9	10	4.9	.7	.0
Little Rock	357	136	153	29.50	29.88	−.10	61.4	−.7	89	10	71	38	15	52	37	53	47	67	5.10	−.1	14	6,573	s.	34	se.	20	10	8	12	6.0	.0	.0
Austin	605	136	148	29.23	29.86		69.4	+1.6	95	30	82	42	14	57	42	58	49	57	1.30	−3.0	9	6,549	s.	38	w.	19	13	9	8	4.5	.0	.0
Brownsville	57	83	100	29.76	29.82		75.2	+1.5	98	27	83	49	15	68	30	68	65	80	.53	−.9	7	8,095	se.	32	n.	14	6	19	5	5.5	.0	.0
Corpus Christi	20	11	78	29.85	29.87	−.08	72.9	+2.1	97	27	79	44	15	67	33	66	63	78	.44	−1.3	4	8,752	s.	32	n.	14	6	7	17	6.8	.0	.0
Dallas	512	220	227	29.31	29.86		65.0		90	9	75	38	15	55	32				4.38	+.1	8	9,691	se.	49	n.	25	13	10	7	3.8	.0	.0
Forth Worth	670	106	114	29.14	29.84	−.10	66.0	+1.0	91	9	78	40	14	54	40	53	43	50	1.57	−2.4	6	7,450	sw.	29	nw.	24	12	8	10	4.8	.0	.0
Galveston	54	106	114	29.82	29.88	−.09	70.5	+1.8	86	27	75	47	15	66	21	65	62	80	.46	−2.6	4	8,471	se.	30	nw.	14	8	13	9	5.3	.0	.0
Houston	138	292	314	29.74	29.89		70.8	+1.5	93	28	80	41	15	61	29				.63	−3.0	8	9,339	se.	35	se.	4	10	11	9	5.0	.0	.0
Palestine	510	64	72	29.36	29.89	−.07	66.0	.0	88	9	77	37	15	55	34	57	51	65	4.14	−.3	10	6,151	s.	25	nw.	15	13	8	9	4.4	.0	.0
Port Arthur	34	58	66	29.85	29.89		70.3		87	27	78	42	15	63	32	62	60	84	.89	−2.1	6	6,560	s.	27	ne.	12	10	15	5	4.7	.0	.0
San Antonio	693	242	301	29.13	29.84	−.11	71.6	+2.5	95	30	83	41	15	60	33	59	50	55	1.30	−1.9	7	8,662	s.	32	nw.	14	11	11	8	5.0	.0	.0
Taylor	571	38	51	29.28	29.88	−.07	68.6	+1.1	95	30	82	40	14	56	45				.77	−3.0	6	7,289	s.	31	se.	4	14	10	6	4.0	.0	.0

TABLE 1.—*Climatological data for Weather Bureau stations, April 1933*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Ohio Valley and Tennessee							54.9	+0.1										66	4.03	+.3										5.8		
Chattanooga	762	190	215	29.14	29.95	−0.08	50.6	−0.7	79	10	69	40	4	50	28	51	45	62	2.70	−2.2	10	6,324	sw.	32	w.	3	6	15	9	5.6	0.0	0.0
Knoxville	995	79	97	28.88	29.93	−.10	50.3	+1.3	83	10	70	38	4	48	33	50	41	57	2.56	−1.6	11	4,929	sw.	28	w.	3	11	10	9	4.7	.0	.0
Memphis	399	78	86	29.46	29.88	−.12	61.5	−.3	86	30	69	41	16	54	24	54	50	70	4.93	+.2	14	5,669	sw.	30	n.	10	7	15	8	5.6	.0	.0
Nashville	546	168	191	29.35	29.94	−.07	58.8	−.2	80	30	69	40	12	49	30	51	45	66	4.17	0	15	7,273	s.	35	s.	30	8	11	11	5.7	.0	.0
Lexington	989	193	230	28.87	29.95	−.07	53.2	−1.1	81	29	62	33	23	44	36	-----	-----	-----	4.03	+.5	15	9,703	s.	37	sw.	30	15	7	8	4.3	.0	.0
Louisville	525	188	234	29.34	29.93	−.08	54.9	−1.5	83	30	64	36	23	46	34	48	41	66	5.81	+1.9	14	8,124	s.	35	nw.	25	8	7	15	6.2	.0	.0
Evansville	431	76	116	29.44	29.91	−.09	56.3	−.4	80	30	65	39	23	48	29	49	43	65	5.10	+1.2	14	7,282	s.	34	sw.	30	8	10	12	5.9	.0	.0
Indianapolis	822	194	230	29.02	29.91	−.09	52.1	.0	81	30	61	32	23	43	34	45	38	65	4.16	+.5	15	8,479	s.	34	sw.	30	6	7	17	6.9	T.	.0
Terre Haute	575	96	129	29.28	29.90	-----	53.4	-----	82	30	63	34	4	44	34	46	40	68	3.37	−.3	14	7,979	s.	35	s.	30	11	9	10	5.7	T.	.0
Cincinnati	627	11	51	29.24	29.92	−.09	52.9	+.5	81	30	63	31	23	43	37	47	42	71	4.46	+1.3	15	6,336	s.	27	s.	30	7	10	13	6.5	.0	.0
Columbus	822	216	230	29.05	29.93	−.09	51.9	+.7	80	29	61	31	23	43	29	45	39	68	3.15	+.3	15	8,360	sw.	35	sw.	11	7	9	14	6.1	T.	.0
Dayton	809	137	173	28.96	29.92	-----	51.6	0	80	30	60	31	23	43	31	45	39	67	4.24	+1.0	15	6,925	s.	30	s.	30	5	14	11	6.3	T.	.0
Elkins	1,947	59	67	27.92	29.98	−.05	50.1	+1.3	83	29	63	25	13	38	46	43	36	67	4.01	+.4	18	5,476	w.	29	w.	2	6	9	15	6.5	T.	.0
Parkersburg	637	77	82	29.31	29.97	−.06	54.3	+.9	83	29	65	34	23	44	36	46	39	65	3.47	+.3	11	4,870	se.	23	w.	2	10	13	7	5.4	.0	.0
Pittsburgh	842	353	410	29.05	29.96	−.06	51.6	+.4	81	29	62	30	23	42	34	44	36	62	4.25	+1.3	13	7,459	w.	30	nw.	26	6	9	15	6.7	T.	.0
Lower Lake Region							47.3	+1.9										69	2.83	+0.3										6.6		
Buffalo	767	243	280	29.10	29.94	−.07	44.8	+2.0	75	29	53	28	27	37	29	40	36	75	2.05	−.5	17	10,858	sw.	40	sw.	28	8	6	16	6.5	1.0	.0
Canton	448	10	61	29.46	29.95	-----	43.8	+1.3	76	30	53	22	23	35	35	-----	-----	-----	3.99	+1.8	16	7,083	e.	30	w.	24	4	11	15	6.9	1.1	.0
Ithaca	836	74	100	29.05	29.96	-----	48.3	+3.3	79	30	58	25	23	38	34	42	35	66	2.50	.0	14	7,852	nw.	35	s.	11	8	3	19	7.2	2.4	.0
Oswego	335	71	85	29.59	29.96	−.05	46.1	+2.5	82	30	54	28	27	38	30	41	36	69	3.23	+.9	17	8,029	se.	32	n.	22	6	10	14	6.5	2.6	.0
Rochester	523	86	102	29.39	29.97	−.04	47.2	+2.3	85	30	56	27	27	39	34	42	35	64	2.76	+.4	19	6,834	w.	29	w.	24	9	7	14	6.3	.4	.0
Syracuse	596	65	79	29.33	29.98	−.03	48.4	+4.0	84	30	57	26	13	39	38	-----	-----	-----	3.65	+1.2	15	5,884	e.	24	nw.	4	7	7	16	6.6	.7	.0
Erie	714	130	166	29.17	29.94	−.08	47.4	+2.3	77	30	56	30	23	39	31	42	38	73	2.80	+.1	13	9,628	w.	34	se.	6	10	6	14	5.6	.2	.0
Cleveland	762	267	337	29.10	29.93	−.09	49.8	+3.6	80	29	58	31	26	41	32	43	36	64	2.42	.0	12	9,840	se.	40	s.	11	8	4	18	6.9	T.	.0
Sandusky	629	5	67	29.24	29.92	−.10	47.5	+.3	78	30	55	31	27	40	34	-----	-----	-----	2.48	−.1	11	7,296	sw.	25	sw.	28	6	5	19	6.8	T.	.0
Toledo	628	79	87	29.24	29.92	−.09	47.8	+.2	80	29	55	29	26	40	30	42	36	68	2.45	−.2	17	7,547	e.	29	w.	6	10	6	14	6.1	T.	.0
Fort Wayne	857	69	84	28.98	29.91	-----	48.9	−.4	79	29	58	32	7	40	33	43	38	71	2.97	−.1	16	7,358	ne.	30	s.	30	5	8	17	7.0	.1	.0
Detroit	730	218	258	29.14	29.93	−.09	47.3	+1.1	73	30	55	28	26	39	28	42	36	70	2.61	+.2	14	7,805	sw.	25	n.	22	6	8	16	6.5	T.	.0
Upper Lake Region							41.6	+0.1										74	3.28	+0.8										6.5		
Alpena	609	13	89	29.26	29.94	−.08	39.4	+.8	73	24	47	25	27	32	34	35	31	74	3.41	+1.2	14	8,262	nw.	31	e.	18	5	7	18	7.0	1.1	.0
Escanaba	612	54	60	29.26	29.94	−.08	38.0	+.1	65	24	45	22	26	31	32	34	29	72	3.93	+1.7	10	7,315	n.	29	n.	24	8	9	13	6.1	.7	.0
Grand Haven	632	54	89	29.22	29.90	−.11	44.5	+.8	78	29	52	26	26	37	37	40	36	75	3.09	+.4	17	8,394	sw.	30	w.	7	4	8	18	7.5	.6	.0
Grand Rapids	707	70	244	29.15	29.92	−.10	46.7	−.3	80	29	55	27	26	38	33	42	36	71	3.88	+1.1	15	9,448	ne.	40	sw.	12	4	8	18	7.5	.9	.0
Houghton	668	64	99	29.20	29.94	−.08	36.0	−1.7	69	23	43	21	12	29	40	-----	-----	-----	2.81	+.5	10	7,409	e.	35	w.	28	11	6	13	5.7	11.4	.0
Lansing	878	6	88	28.96	29.91	-----	45.8	+.2	77	29	55	24	26	36	34	42	38	79	3.35	+.8	13	7,705	n.	29	w.	28	6	6	18	6.7	.2	.0
Ludington	637	60	66	29.20	29.91	-----	43.2	+1.3	74	29	50	28	7	36	33	39	35	78	4.48	+1.9	17	7,731	n.	27	sw.	28	8	10	12	5.6	2.7	.0
Marquette	734	77	111	29.13	29.94	−.08	37.2	−.6	70	23	44	24	9	31	33	33	29	74	4.32	+1.9	11	6,366	nw.	37	w.	28	8	5	17	6.6	12.5	.0
Port Huron	638	79	120	29.23	29.92	−.10	44.5	+1.5	72	30	53	26	26	36	32	40	36	77	3.66	+1.4	15	8,372	n.	30	ne.	22	6	4	20	7.3	T.	.0
Sault Sainte Marie	614	11	52	29.25	29.95	−.08	38.3	+.9	69	19	46	23	9	31	34	34	28	70	2.75	+.6	12	6,376	nw.	32	nw.	28	10	8	12	5.5	1.2	.0
Chicago	673	7	131	29.18	29.91	−.09	46.8	−.1	80	29	54	33	7	40	30	41	36	71	2.61	−.2	16	8,846	ne.	30	sw.	30	9	8	13	6.1	.1	.0
Green Bay	617	109	141	29.23	29.90	−.11	41.8	−1.4	72	24	49	26	7	34	35	37	32	74	2.54	−.1	14	8,602	ne.	30	ne.	21	6	4	20	7.4	.7	.0
Milwaukee	681	97	221	29.16	29.91	−.08	43.8	.0	72	24	50	30	7	37	34	39	34	73	2.97	+.3	18	10,053	n.	36	n.	21	5	10	15	6.9	.8	.0
Duluth	1,133	5	47	28.70	29.94	−.07	36.5	−.5	73	23	44	19	12	29	36	32	27	73	2.15	+.1	9	10,613	ne.	38	ne.	30	14	3	13	5.3	11.1	.0
North Dakota							40.6	−0.2										68	1.39	−0.3										5.6		
Moorhead	940	50	58	28.91	29.94	−.05	41.4	+.8	76	23	51	18	11	32	43	36	30	68	2.07	−.1	7	7,883	n.	26	e.	29	11	6	13	5.4	6.7	.0
Bismarck	1,674	8	57	28.13	29.93	−.04	42.5	+.4	82	16	53	14	10	32	42	35	28	63	.73	−.8	4	8,194	ne.	30	se.	18	9	8	13	5.8	6.7	.0
Devils Lake	1,478	11	44	28.36	29.96	−.03	38.4	−.4	73	23	47	11	11	29	34	33	28	71	.62	−.9	8	9,122	ne.	31	n.	19	9	4	17	8.2	6.9	.0
Ellendale	1,457	10	56	28.36	29.94	-----	41.4	-----	77	18	53	17	26	30	49	-----	-----	-----	2.34	+.2	6	11,382	ne.	39	nw.	1	10	7	13	5.7	4.4	.0
Grand Forks	833	12	67	-----	-----	-----	40.0	-----	78	23	49	18	11	31	38	35	-----	-----	1.41	-----	8	-----	nw.	35	nw.	28	9	12	9	-----	11.4	.0
Williston	1,878	41	48	27.95	29.96	.00	40.2	−1.8	70	23	50	16	11	31	35	34	29	69	1.20	.0	6	7,814	ne.	27	n.	19	12	10	8	4.9	7.0	.0
Upper Mississippi Valley							49.8	−0.4										68	2.48	−0.4										5.9		
Minneapolis	918	102	208	28.89	29.88	-----	44.8	−1.6	74	23	54	28	11	36	31	-----	-----	-----	1.43	−.8	11	8,699	nw.	30	e.	8	11	5	14	5.8	.9	.0
St. Paul	837	114	149	29.00	29.92	−.07	45.2	−.4	73	23	54	26	12	36	32	-----	-----	-----	1.32	−1.0	9	7,130	nw.	25	nw.	11	11	5	14	5.4	1.3	.0
La Crosse	714	11	48	29.12	29.90	−.08	46.2	−1.0	80	29	55	26	14	37	35	40	33	66	2.24	−.2	8	4,733	nw.	17	w.	12	7	9	14	6.2	.9	.0
Madison	974	70	78	28.84	29.91	−.08	44.1	−1.3	77	29	52	29	7	36	31	39	33	71	3.75	+1.0	14	7,210	ne.	27	s.	29	5	9	16	6.9	5.1	.0
Wausau	1,247	4	62	28.57	29.92	-----	42.2	-----	70	24	52	21	8	32	33	-----	-----	-----	4.13	+1.5	8	5,803	e.	23	e.	5	11	8	11	5.2	2.3	.0
Charles City	1,015	10	51	28.82	29.90	−.08	46.3	−.1	78	29	56	27	27	36	37	40	33	65	2.49	.0	9	5,996	se.	24	se.	29	11	9	10	5.1	T.	.0
Davenport	606	118	143	29.23	29.89	−.09	49.6	−.3	77	28	59	32	11	40	31	43	37	67	2.56	−.1	12	9,177	ne.	46	s.	29	9	7	14	6.3	.4	.0
Des Moines	861	5	90	28.97	29.88	−.09	50.2	+.1	76	28	60	29	7	40	38	43	35	62	.93	−2.0	8	7,091	e.	32	s.	29	10	7	13	5.9	T.	.0
Dubuque	700	81	96	29.14	29.90	−.08	47.8	−.8	78	29	56	31	13	39	31	41	35	65	1.53	−1.3	8	5,748	nw.	20	sw.	29	5	7	18	6.9	1.4	.0
Keokuk	614	64	78	29.22	29.89	−.09	52.0	−.3	80	28	62	32	11	42	34	45	38	64	1.59	−1.4	9	6,741	nw.	25	nw.	2	7	9	14	6.3	T.	.0
Cairo	358	87	93	29.50	29.89	−.10	58.5	+.4	84	30	66	42	7	51	25	53	50	78	3.68	.0	12	6,982	s.	30	sw.	30	8	10	12	6.1	.0	.0
Peoria	609	11	45	29.24	29.90	−.09	50.9	.0	79	28	61	31	27	41	36	45	39	70	3.05	−.3	12	6,525	ne.	24	sw.	30	10	7	13	5.5	T.	.0
Springfield, Ill	636	5	191	29.20	29.88	−.10	53.3	+.6	84	30	63	34	23	43	37	47	43	73	2.57	−.9	15	9,188	s.	32	s.	30	11	4	15	5.5	T.	.0
Hannibal	534	74	109	29.30	29.87	−.11	53.3	−.1	83	9	63	33	27	44	31	-----	-----	-----	2.13	−1.1	11	7,705	e.	34	s.	30	8	10	12	6.2	T.	.0
St. Louis	568	265	303	29.27	29.87	−.11	55.5	−.3	86	30	65	36	7	46	33	49	43	70	3.84	.0	12	8,100	s.	44	s.	29	8	10	12	5.6	T.	.0
Missouri Valley							51.6	+0.6										60	2.17	−0.6										5.2		
Columbia, Mo	784	6	84	29.04	29.88	−.10	54.4	−.5	87	9	64	32	7	44	36	-----	-----	-----	1.72	−2.0	12	6,980	n.	30	s.	29	13	6	11	5.1	T.	.0
Kansas City	963	10	86	28.83	29.87	−.10	55.1	+.3	84	9	65	31	13	46	35	46	39	60	1.82	−1.3	7	8,345	e.	30	sw.	30	10	10	10	5.4	2.0	.0
St. Joseph	967	11	49	28.82	29.86	-----	54.6	-----	85	8	65	31	11	44	35	45	36	58	3.42	+.4	8	7,505	se.	31	se.	19	13	9	8	4.9	T.	.0
Springfield, Mo	1,324	98	104	28.46	29.86	−.11	55.2	−.8	86	9	65	32	15	46	33	48	42	69	6.61	+2.8	12	7,985	se.	31	s.	4	18	5	7	3.8	5.2	.0
Iola	984	11	50	28.79	29.83	−.12	57.4	+1.2	84	9	70	30	11	44	41	-----	-----	-----	3.49	+.5	8	-----	s.	-----	-----	-----	9	12	9	-----	.0	.0
Topeka	987	92	107	-----	-----	-----	55.6	+.9	87	8	67	32	7	44	45	-----	-----	-----	3.82	+1.0	8	7,840	nw.	29	sw.	12	13	10	7	4.1	.1	.0
Lincoln	1,189	11	81	28.60	29.86	−.08	51.2	−.3	80	28	62	28	14	41	38	43	34	58	1.21	−1.3	3	8,052	n.	30	n.	12	11	9	10	5.6	T.	.0
Omaha	1,105	115	122	28.70	29.88	−.07	52.0	+.8	79	28	62	31	11	42	34	43	33	54	.38	−2.1	4	7,136	nw.	30	nw.	12	10	8	12	5.4	T.	.0
Valentine	2,598	47	54	27.18	29.91	−.03	46.2	+.5	82	28	58	18	14	34	44	39	32	65	2.25	+.4	9	8,651	nw.	35	se.	18	7	10	13	6.1	.9	.0
Sioux City	1,135	94	164	28.66	29.88	−.07	49.2	+1.4	75	24	60	26	14	39	37	41	32	57	.72	−2.0	5	8,959	nw.	29	nw.	6	8	9	13	6.0	.2	.0
Huron	1,306	59	74	28.51	29.92	−.04	46.2	+1.1	75	18	58	20	14	35	38	38	29	58	.31	−1.9	6	8,289	n.	31	ne.	29	12	11	7	5.0	T.	.0
Pierre	1,572	70	75	28.22	29.90	−.05	47.6	+.8	82	16	58	24	10	37	44	40	30	57	1.26	−.6	8	8,533	nw.	35	n.	2	12	11	7	5.2	3.2	.0
Yankton	1,233	49	57	28.59	29.91	−.04	49.1	+1.2	76	29	60	26	14	38	40	-----	-----	-----	1.15	−1.7	5	7,286	nw.	24	nw.	1	8	11	11	5.8	T.	.0

TABLE 1.—*Climatological data for Weather Bureau stations, April 1933*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F		°F	°F.		°F	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Northern Slope							41.4	−1.8										64	2.57	+1.0										6.2		
Billings	3,140	5	-----	-----	-----	-----	45.8	-----	78	15	59	14	13	33	45	-----	-----	-----	.84	-----	9	-----	nw.	-----	-----	-----	6	7	17	-----	-----	-----
Havre	2,505	11	67	27.32	29.99	+0.06	42.0	−1.7	73	22	53	17	11	31	41	35	28	65	1.44	+0.4	9	7,648	sw.	34	nw.	3	7	10	13	6.3	14.2	.0
Helena	4,124	89	113	25.75	29.98	+.01	41.1	−2.4	70	25	51	14	10	31	36	34	26	60	1.50	+.4	9	6,654	sw.	32	w.	3	3	11	16	7.4	5.4	.0
Kalispell	2,973	48	56	26.91	29.98	+.02	42.4	−1.2	75	25	53	21	9	32	38	38	33	74	1.43	+.6	11	5,030	nw.	33	nw.	3	3	12	15	6.9	11.0	.0
Miles City	2,371	48	55	27.41	29.99	+.03	44.0	−.7	73	15	53	19	11	35	38	37	31	66	1.20	+.1	7	6,380	n.	34	nw.	4	5	15	10	6.2	2.7	.0
Rapid City	3,259	50	58	26.50	29.94	−.01	43.1	−1.2	80	16	53	17	6	33	41	37	30	65	2.78	+.8	11	7,379	n.	35	nw.	3	6	12	12	6.3	5.0	.0
Cheyenne	6,088	84	101	23.88	29.90	−.01	37.8	−3.1	68	16	49	8	10	26	42	31	22	59	4.79	+2.8	13	10,384	n.	46	w.	3	8	12	10	5.9	28.4	T.
Lander	5,372	60	68	24.54	29.94	.00	38.2	−4.2	74	27	50	7	13	26	38	32	24	62	4.07	+2.0	11	4,365	sw.	46	sw.	3	14	7	9	4.6	40.3	.0
Sheridan	3,790	10	47	26.03	29.97	-----	39.9	-----	73	28	52	8	13	28	42	34	29	71	2.83	+.9	14	5,376	nw.	37	nw.	3	7	12	11	6.3	22.1	.0
Yellowstone Park	6,241	11	48	23.80	29.98	+.02	35.0	−2.0	62	28	46	5	10	24	38	29	22	64	.91	−.6	14	6,839	sw.	28	n.	3	4	14	12	6.6	5.4	T.
North Platte	2,821	11	51	26.94	29.86	−.06	49.2	+.6	79	28	62	18	14	37	43	40	31	59	4.78	+2.7	10	7,533	n.	30	n.	2	11	8	11	5.7	.2	.0
Middle Slope							52.9	−0.5										52	2.86	+0.6										4.4		
Denver	5,292	106	113	24.59	29.86	−.04	45.2	−1.9	75	17	57	15	14	34	39	35	23	52	4.09	+2.0	11	6,977	s.	38	ne.	12	12	12	6	5.1	33.8	.0
Pueblo	4,685	80	86	25.16	29.84	−.04	47.0	−3.1	77	18	61	13	14	33	46	36	24	50	2.60	+1.3	10	5,631	n.	32	nw.	29	11	12	7	4.8	14.9	.0
Concordia	1,392	50	58	28.41	29.89	−.04	52.8	−.7	80	7	64	28	11	42	47	44	34	55	2.48	+.1	6	7,019	n.	32	s.	29	14	3	13	5.2	T.	.0
Dodge City	2,509	10	86	27.27	29.86	−.04	53.6	.0	89	18	67	21	6	40	44	42	31	49	4.06	+2.1	7	9,754	n.	41	ne.	13	18	5	7	3.6	T.	.0
Wichita	1,358	85	93	28.41	29.83	−.10	57.5	+1.1	87	18	69	31	6	46	36	46	35	50	.86	−2.0	3	9,119	n.	37	sw.	29	17	8	5	4.1	.0	.0
Oklahoma City	1,214	10	47	28.56	29.83	−.09	61.2	+1.4	87	18	73	35	13	49	33	50	40	55	3.05	−.2	6	7,799	s.	30	sw.	29	18	7	5	3.6	T.	.0
Southern Slope							62.1	−0.7										40	0.36	−1.4										3.3		
Abilene	1,738	10	52	28.05	29.84	−.06	65.6	+1.2	93	18	80	38	14	52	43	49	33	38	.43	−2.3	3	8,254	s.	35	sw.	29	18	7	5	3.4	.0	.0
Amarillo	3,676	10	49	26.13	29.83	−.04	55.8	.0	85	17	70	24	14	41	39	41	25	40	.64	−1.2	7	8,132	sw.	32	sw.	29	17	8	5	3.5	.1	.0
Big Spring	2,537	5	62	27.26	29.85	-----	62.4	-----	90	28	78	32	14	47	43	47	32	41	.10	-----	1	-----	s.	-----	-----	-----	23	3	4	2.6	.0	.0
Del Rio	944	64	71	28.82	28.79	−.10	71.1	+.5	96	28	84	42	15	58	42	56	44	46	.19	−1.6	2	6,880	se.	34	nw.	19	13	8	9	4.7	.0	.0
Roswell	3,566	75	85	26.25	29.83	−.02	56.0	−4.6	81	17	72	23	14	40	49	42	25	37	.16	−.7	1	6,977	sw.	34	sw.	29	20	6	4	2.4	T.	.0
Southern Plateau							54.9	−2.4										39	0.59	+0.2										3.0		
El Paso	3,778	152	175	26.08	29.82	−.01	60.5	−2.9	81	2	74	33	14	47	38	44	23	29	.09	−.2	1	9,654	w.	48	w.	19	23	5	2	2.1	T.	.0
Albuquerque	4,972	51	66	24.94	29.81	-----	48.6	-----	76	16	65	20	14	32	52	35	16	35	.39	-----	5	8,013	w.	41	s.	18	16	6	8	4.2	.6	.0
Santa Fe	7,013	38	53	23.13	29.84	−.03	42.8	−3.9	66	2	55	11	14	30	37	32	16	42	.80	−.2	7	5,193	sw.	25	sw.	4	12	8	10	4.8	10.9	.0
Flagstaff	6,907	10	59	23.24	29.82	−.02	39.0	−3.2	69	2	54	12	19	24	47	31	-----	59	1.14	-----	7	-----	sw.	29	sw.	17	11	10	9	-----	4.0	T.
Phoenix	1,108	10	107	28.70	29.85	−.02	64.7	−2.3	90	4	79	38	20	50	42	48	28	33	1.11	+.7	5	4,878	e.	29	sw.	28	24	1	5	2.5	.0	.0
Yuma	141	9	54	29.72	29.87	−.02	66.5	−3.0	97	3	81	40	19	52	43	51	33	36	.91	+.8	2	4,949	w.	24	n.	13	27	2	1	1.2	.0	.0
Independence	3,957	6	27	25.89	29.90	.00	56.1	+1.0	84	3	70	30	10	42	39	40	-----	-----	.05	−.1	1	-----	nw.	-----	-----	-----	18	7	5	-----	.0	.0
Middle Plateau							46.3	−2.1										44	0.43	−0.6										4.5		
Reno	4,532	74	81	25.40	29.92	−.05	48.0	+.7	75	3	62	21	10	34	43	37	24	42	.06	−.4	3	6,132	w.	30	w.	29	14	12	4	3.7	T	.0
Tonopah	6,090	12	20	-----	-----	-----	45.4	-----	68	3	56	20	9	35	27	35	22	44	.32	-----	3	-----	nw.	-----	-----	-----	-----	-----	-----	-----	-----	-----
Winnemucca	4,344	18	56	25.56	29.96	.00	45.7	−1.0	75	28	61	12	10	30	51	35	22	47	.27	−.6	4	6,339	ne.	32	nw.	6	16	7	7	3.8	.7	.0
Modena	5,473	10	46	24.51	29.85	−.03	42.8	−3.2	71	3	58	14	10	28	44	33	17	42	.23	−.7	5	8,027	sw.	41	sw.	17	12	8	10	4.9	.3	.0
Salt Lake City	4,360	163	203	25.54	29.92	.00	46.8	−2.8	73	15	57	24	10	37	36	37	26	48	1.28	−.8	9	6,542	nw.	34	e.	21	10	11	9	5.1	4.4	.0
Grand Junction	4,602	60	68	25.26	29.84	−.04	48.0	−4.4	73	27	61	21	14	35	36	36	21	41	.32	−.5	7	5,725	se.	28	nw.	4	10	10	10	5.0	1.9	.0
Northern Plateau							48.8	−1.0										51	0.70	−0.4										5.5		
Baker	3,471	48	53	26.43	30.03	+.03	43.1	−2.1	74	27	55	20	10	31	38	36	27	56	1.01	−.1	8	5,562	n.	22	n.	3	11	7	12	5.5	1.1	.0
Boise	2,739	79	87	27.12	29.99	+.01	48.6	−1.8	76	24	60	25	13	37	33	39	29	52	.74	−.4	5	4,620	nw.	29	nw.	3	12	8	10	5.3	T	.0
Lewiston	757	40	48	29.21	30.02	+.03	52.5	−.4	83	24	65	30	4	40	39	-----	-----	-----	.46	−.6	6	3,516	e.	26	nw.	3	8	6	16	6.7	T	.0
Pocatello	4,477	60	68	25.39	29.92	+.02	44.2	−1.8	71	27	54	21	5	34	33	36	26	54	.99	−.4	7	6,672	se.	30	sw.	7	9	5	16	6.1	2.2	.0
Spokane	1,929	101	110	27.94	30.00	+.01	48.4	.0	76	27	59	28	9	38	34	40	39	52	.28	−.8	4	4,956	sw.	24	sw.	3	7	12	11	5.5	3.8	.0
Walla Walla	991	57	65	28.94	30.01	.00	52.6	−.5	80	27	63	32	4	42	30	43	31	46	1.27	−.2	7	4,638	s.	24	sw.	11	11	8	11	5.0	.1	.0
Yakima	1,076	58	67	28.86	30.01	-----	52.2	−.3	84	27	65	29	9	40	35	42	30	46	.16	−.3	3	5,113	nw.	27	nw.	3	14	10	6	4.1	T	.0
North Pacific Coast Region							48.8	−0.3										70	0.92	−1.9										5.9		
North Head	211	11	56	29.90	30.14	+.09	46.2	−1.3	68	20	50	34	8	42	20	43	40	82	1.47	−2.7	15	10,343	n.	42	n.	5	9	9	12	5.7	.0	.0
Port Angeles	29	8	53	-----	30.11	-----	45.9	-----	63	21	54	32	10	38	23	-----	-----	-----	.23	−1.3	5	5,548	s.	25	w.	14	7	14	9	-----	.0	.0
Seattle	125	215	250	29.96	30.09	+.06	49.4	.0	72	27	57	34	7	42	26	43	36	64	.84	−1.5	8	5,816	ne.	28	s.	11	6	12	12	6.3	T.	.0
Tacoma	194	172	201	29.89	30.10	+.07	48.6	−.1	72	21	57	34	10	40	30	-----	-----	-----	1.02	−1.8	8	6,046	n.	26	sw.	11	6	9	15	6.4	.0	.0
Tatoosh Island	86	9	53	30.01	30.11	+.11	46.0	−.1	64	20	50	38	16	42	18	43	40	83	1.40	−4.2	12	7,387	w.	33	nw.	6	5	5	20	7.1	.0	.0
Medford	1,329	29	58	28.62	30.03	-----	51.8	-----	84	27	66	26	9	37	45	43	34	59	.63	−.6	6	4,808	nw.	30	nw.	29	11	11	8	4.9	.5	.0
Portland, Oreg.	153	68	106	29.94	30.10	+.04	51.6	−.2	76	27	62	34	10	42	32	45	38	65	.95	−1.9	11	4,776	nw.	21	ne.	20	10	7	13	5.9	1.7	.0
Roseburg	510	75	99	29.54	30.10	+.03	51.0	.0	78	27	62	33	17	40	37	44	37	64	.85	−1.4	9	3,959	n.	21	n.	25	12	7	11	5.0	T.	.0
Middle Pacific Coast Region							55.9	+0.2										67	0.29	−1.6										3.7		
Eureka	62	73	89	30.03	30.10	−.01	48.2	−1.7	60	2	53	34	8	43	21	46	44	88	.97	−2.4	10	6,096	n.	24	n.	6	11	9	10	5.3	T.	.0
Red Bluff	330	5	58	29.60	29.95	−.08	61.6	+2.6	92	2	76	38	8	48	41	51	40	51	.22	−1.5	4	5,621	nw.	26	nw.	7	19	6	5	3.1	.0	.0
Sacramento	69	106	117	29.88	29.95	−.06	58.2	+.1	83	27	70	36	17	46	35	49	40	57	.03	−1.5	1	6,676	s.	25	nw.	12	22	8	0	1.8	.0	.0
San Francisco	155	208	243	29.83	30.00	−.05	55.5	+.5	82	2	62	43	18	49	28	49	44	71	.06	−1.6	2	5,880	w.	29	nw.	25	12	13	5	4.3	.0	.0
San Jose	141	12	110	29.85	30.00	-----	56.2	−.5	87	14	68	34	9	44	37	-----	-----	-----	.15	−.9	3	4,970	nw.	24	sw.	28	13	9	8	4.1	.0	.0
South Pacific Coast Region							59.3	−0.1										63	0.81	−0.2										4.4		
Fresno	327	89	98	29.60	29.95	−.04	61.0	+.8	88	14	74	36	18	48	35	50	39	51	.12	−.8	2	5,592	nw.	30	nw.	8	16	12	2	2.9	.0	.0
Los Angeles	338	159	191	29.62	29.98	−.01	59.1	−.3	82	14	67	42	18	51	29	51	45	67	.56	−.5	4	4,450	sw.	16	sw.	17	15	5	10	4.4	.0	.0
San Diego	87	62	70	29.88	29.97	−.02	57.8	−.7	77	14	64	45	18	52	25	52	48	72	1.75	+1.0	5	5,228	w.	28	w.	17	8	10	12	5.9	.0	.0
West Indies																																
San Juan, P.R.	82	9	54	29.87	29.96	-----	76.9	+.3	91	26	82	69	19	71	16	-----	-----	-----	6.36	+2.0	10	7,497	e.	28	e.	5	8	20	2	4.5	.0	.0
Panama Canal																																
Balboa Heights	118	6	97	-----	[1] 29.82	+.04	81.6	.0	92	29	90	70	10	73	22	-----	-----	[1] 74	3.46	+.5	3	5,487	nw.	23	n.	17	0	21	9	6.4	.0	.0
Cristobal	36	6	97	-----	[1] 29.85	.00	82.7	+.9	89	30	87	76	10	78	13	75	73	[1] 74	.35	−3.8	5	8,548	n.	24	n.	8	8	15	7	5.4	.0	0
Alaska																																
Fairbanks	455	11	44	[2] 29.33	[2] 29.86	-----	32.1	-----	54	30	43	−5	1	21	43	28	20	61	.17	-----	4	3,719	n.	19	ne.	13	9	11	10	5.2	2.0	.0
Juneau	80	11	50	[2] 29.93	[2] 30.02	-----	39.2	-----	52	30	45	28	8	34	21	36	30	72	7.11	-----	19	5,184	s.	27	e.	13	5	3	22	7.9	5.5	.0
Hawaiian Islands																																
Honolulu	38	86	100	[2] 30.01	[2] 30.05	-----	71.9	−1.1	80	14	77	59	4	67	14	65	61	70	.29	−1.8	10	7,003	e.	25	ne.	1	8	16	6	5.1	.0	.0

[1] Observations taken bihourly.

[2] Pressure not reduced to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, April 1933*

Stations	Altitude above mean sea level Jan. 1, 1919	Pressure			Temperature of the air						Precipitation		
		Station reduced to mean of 24 hours	Sea level reduced to mean of 24 hours	Departure from normal	Mean max. + mean min. ÷2	Departure from normal	Mean maximum	Mean minimum	Highest	Lowest	Total	Departure from normal	Total snowfall
	Feet	*In.*	*In.*	*In.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	*In.*	*In.*	*In.*
Cape Race, N.F	99							28.4		18	3.64		T.
Sydney, C.B.I	48	29.98	30.03	+0.14	38.0	+3.0	47.5	28.5	65	19	2.35	−1.50	2.5
Halifax, N.S	88	29.90	30.01	+.05	39.2	+1.4	47.0	31.4	65	20	3.41	−.77	T.
Yarmouth, N.S	65	29.88	29.95	−.01	41.5	+2.6	48.7	34.2	66	24	3.65	−.17	T.
Charlottetown, P.E.I	38	29.94	29.98	+.08	37.6	+2.4	44.7	30.5	57	18	1.22	−1.43	2.1
Chatham, N.B	28	29.88	29.91	+.01	36.2	+.7	45.2	27.1	70	13	3.48	+.85	2.1
Father Point, Que	20	29.97	29.99	+.06	34.9	+1.7	40.9	28.9	54	16	4.67	+3.09	42.7
Quebec, Que	296	29.66	29.99	.00	37.9	+2.8	43.2	32.6	62	20	4.01	+1.92	23.2
Doucet, Que	1,236				33.6		43.0	24.3	64	7	3.45		19.1
Montreal, Que	187	29.74	29.95	−.05	42.2	+2.5	49.0	35.5	67	26	4.12	+1.88	2.5
Ottawa, Ont	236	29.69	29.96	−.06	42.3	+2.3	50.3	34.3	76	25	3.06	+1.56	1.8
Kingston, Ont	285	29.64	29.96	−.06	44.0	+4.0	51.0	37.0	72	28	3.97	+2.18	.0
Toronro, Ont	379	29.53	29.94	−.08	45.0	+4.2	52.6	37.4	70	27	2.55	+.18	.8
Cochrane, Ont	930				33.9		41.8	26.0	70	13	3.51		10.8
White River, Ont	1,244	28.60	29.94	−.10	32.5	−.5	43.0	21.9	68	6	2.62	+1.37	9.1
London, Ont	808				44.3		53.1	35.5	70	24	3.56		.4
Southampton, Ont	656	29.21	29.94	−.09	41.9	+3.2	50.5	33.3	70	25	2.87	+1.07	1.0
Parry Sound, Ont	688	29.22	29.92	−.10	42.1	+4.5	50.6	33.6	72	22	4.40	+2.49	3.6
Port Arthur, Ont	644	29.22	29.93	−.10	35.1	+1.6	42.2	28.1	75	19	2.43	+.71	16.3
Winnipeg, Man	760	29.14	29.98	−.04	36.9	+1.0	45.3	28.6	72	14	.98	−.07	7.8
Minnedosa, Man	1,690	28.14	29.99	−.02	34.9	−1.1	43.8	26.1	71	13	.62	−.44	3.3
Le Pas, Man	860				31.4		41.1	21.7	68	10	.70		5.0
Qu'Appelle, Sask	2,115												
Moose Jaw, Sask	1,759				38.5		49.0	28.0	74	15	.98		1.3
Swift Current, Sask	2,392												
Medicine Hat, Alb	2,365	27.42	29.92	.00	40.7	−3.8	50.6	30.8	72	18	1.36	+.62	4.0
Calgary, Alb	3,540	26.25	29.98	+.08	34.7	−4.9	45.0	24.4	66	10	2.22	+1.58	21.0
Banff, Alb	4,521												
Prince Albert, Sask	1,450	28.45	30.06	+.08	36.1	.0	46.0	26.2	73	12	.47	−.36	4.7
Battleford, Sask	1,592												
Edmonton, Alb	2,150												
Kamloops, B.C	1,262												
Victoria, B.C	230	29.84	30.10	+.09	47.6	+.8	54.0	41.2	63	36	.34	−2.03	.0
Barkerville, B.C	4,180												
Estevan Point, B.C	20												
Prince Rupert, B.C	170												
Hamilton, Ber	151												

LATE REPORTS FOR MARCH 1933

Moose Jaw, Sask	1,759				27.4		37.5	17.2	67	−14	.51		4.5
Swift Current, Sask	2,392												
Medicine Hat, Alb	2,365												
Calgary, Alb	3,540												
Banff, Alb	4,521												
Prince Albert, Sask	1,450												
Battleford, Sask	1,592												
Edmonton, Alb	2,150												
Kamloops, B.C	1,262	28.60	29.92	0.00	39.3	+3.2	46.0	32.7	57	21	.41	−.16	2.2
Victoria, B.C	230												
Barkerville, B.C	4,180												
Estevan Point, B.C	20				42.0		47.3	36.7	52	30	11.35		.0
Prince Rupert, B.C	170				38.5		44.7	32.3	59	23	6.89		2.8
Hamilton, Ber	151												

SEVERE LOCAL STORMS, APRIL 1933

[Compiled by Mary O. Souder]

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A revised list of tornadoes will appear in the Annual Report of the Chief of Bureau]

Place	Date	Time	Width of path (yards)	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Madison (near), Fla	2-3	3 p.m.			$1,500	Wind and hail	Slight damage to crops	Official, U.S. Weather Bureau.
Havre, Mont	3	Noon and 5 p.m.				Snow squalls	Poles blown down and electric current off for 4 hours; property loss.	Do.
Quitman, Ga	4	7:43 p.m.	35			Tornado	Electric poles and wires blown down, houses razed, trees uprooted.	Do.
Center Hill (near), Fla	5	4 p.m.	440		1,000	Wind	Property damaged; path 5 miles long	Do.
Gaffney (near), S.C	6	3-4 p.m.		1		Electrical	Man killed by lightning	Do.
Raleigh (south of), N.C	6	10 p.m.			35,000	Thunder squall	7 airplanes badly damaged; fruit trees blown down; barn with cows destroyed by lightning.	Do.
Fairforest, Chesnee, and and Cowpens, S.C.	6	P.m.	[1] 2-10		10,000	do	Property damaged by wind; path 20 miles long	Do.
Weston, W.Va	6	do			2,200	Severe wind	Property damaged	Do.
Canal Point, Fla	7	1:30 a.m.	[1] 12		3,000	Hail	Damage chiefly to crops	Do.
Choteau County, Mont	7			1		Severe blizzard	Considerable suffering among livestock causing loss to ranchers; boy froze when he lost his way going home.	Do.
Jefferson County, Kans	8	4 p.m.				Tornado	No injuries or real damage reported; no buildings in path which was 3 miles long.	Do.
Liberty and Toole Counties, Mont.	8-9					Snowstorm	Deepest snow reported for any April; roads blocked; automobiles stalled; 500 sheep lost.	Do.
Evansville, Ind	9	8:39-8:51 a.m.			35,000	Hail, electrical	Damage to greenhouses, electric signs, windowpanes, and automobile tops.	Do.
Sanford, Fla	9	2:15 p.m.	880			Wind and hail	Considerable damage to crops; several roofs blown off.	Do.
Fort Meade, Fla	9	2:30 p.m.	[1] 2		5,000	Hail	Crops damaged	Do.
Penelope, Midlothian, Emhouse, Everman, Rice, and Kennedale, Tex.	9	5:30-6:30 p.m.	[1] ½-60		45,000	Wind	Indication of tornado at Kennedale; damage to crops light.	Do.
Indiantown, Fla	9	6 p.m.	[1] 2-3			Hail	Crops total loss in path	Do.
Moline and Rock Island, Ill.	9				50,000	do	Nurserymen suffered most severe loss; other property damage.	Do.
Davenport, Iowa	9				50,000	Heavy hail	Damage mostly to greenhouses, roofs, windows, and automobile tops.	Do.
Grant County, Wis	9-10				30,000	Heavy rain	Property loss	Do.
Ash Flat, Ark. (4 miles south).	10	2:30 p.m.	867		4,500	Tornado	Houses, barns, and fences destroyed; path 7 miles long.	Do.
Sitka to Strawberry River, Ark.	10				2,500	Wind	Houses and barns damaged	Do.
Texarkana, Ark. (15 miles northwest).	10					Tornado	Originated in Texas; property damage unknown	Do.
Rena (near), Ark	13			2		Electrical	Lightning caused death of 2 persons	Do.
New England	13			4		Snow	Power lines, telephone and telegraph systems, and trees damaged; communities cut off for hours from wire communication; bus and street railway schedules disarranged; many persons injured.	Do.
De Ridder, La	14	10:30-11 a.m.	[1] 12			Hail	Damage to truck, especially tomatoes	Do.
North-Central Vermilion Parish, La.	14	4:40 p.m.	[1] 10		6,500	Heavy hail	Path 10 miles long	Do.
Northwestern Arkansas	14-15					Heavy snowfall	Telegraph and telephone wires broken; several thousand dollars' damage; heaviest snowfall for April in history of State.	Do.
Myrtle Beach (near), S.C.	16				1,500	Excessive rain	Bridges and approaches washed out on highway; automobiles wrecked; persons injured.	Do.
Englewood and South Denver, Colo.	18	P.m.	10			Tornado	Property damaged	Do.
Laurens, S.C	18				6,000	Thunderstorm	Residence burned by lightning	Do.
Louisa, Chesterfield, and Dinwiddie counties, Va.	19	2-4 p.m.	[1] 1-2		28,000	Hail	Entire damage not estimated; loss mostly to nurserymen.	Do.
Kiowa County, Okla	19	3-4 p.m.			1,000	do	Damage to property	Do.
Gaffney, S.C., south of	19	3-4 p.m.	[1] ½-2		2,500	do	Damage to young crops, path 10 miles long	Do.
Woods County, Okla. (Capron to Dacoma).	19	4 p.m.	[1] 1		20,000	do	Damage to crops and property; path 4 miles long.	Do.
Pawnee and Barton counties, Kans.	19	5 p.m.	[1] 8		10,000	Heavy hail	Much damage to residences and outbuildings; shingles torn from buildings; many chickens killed.	Do.
Norton and Phillips Counties, Kans.	19	5:15 p.m.	50-400		12,000	Tornado	Damage to farm property; 2 persons slightly injured; path 6 miles long.	Do.
Trego County, Kans	19	7 p.m.	[1] 1		200	Heavy hail	Damage to windows and trees	Do.
Okeene, Okla. (7 miles west).	19	7-8 p.m.	880			Hail	Slight damage to crops; few windowpanes broken; path 3½ miles long.	Do.
Chickasha (near), Okla	19	P.m.		2		Gale	Farmhouse destroyed	Do.
Grady and Tillman Counties, Okla.	19	do		2	271,000	Tornado	30 persons injured; damage to crops and property.	Do.
Copiah County, Miss	19					Heavy hail	Crops damaged	Do.
Bishopville, S.C. (vicinity of).	19		[1] 2		2,500	Hail	No details	Do.
Wyoming, central and southeastern portions.	19-20					Heavy snowfall	do	Do.
Charleston, S.C	20	11:12-11:25 a.m.				Rain and hail	do	Do.
East and West Baton Rouge Parishes, La.	20	8:40 p.m.	[1] 5		15,000	Heavy hail and wind.	Property loss; path 8 miles long	Do.
Sarasota, Fla	21	3:30 a.m.				Hail	Much damage to tender crops	Do.
Chumukla, Fla	22				1,500	do	Crops damaged	Do.
Tripon, Nebr	22	P.m.		6		Tornado	Wires down; no communication; details not reported.	Do.
Southeastern Kansas	22			3		do	2 trucks with 5 passengers overturned several times injuring all 5.	Do.
Callahan, Fla	24	5 p.m.	[1] 2			Heavy hail	Heavy loss to crops; property damaged	Do.
Smiley (near), Tex	24	do	[1] 6		2,000	Hail	Livestock and poultry killed	Do.
Sherman and Greenville, Tex.	25	A.m.				do	Glass in hothouses broken; fruit crop damaged	Do.
Madison (near), Fla	25	5 p.m.			5,000	Wind	Damage mostly to property	Do.
Greenville, Grand Prairie, and Dallas, Tex.	25	5-6:30 p.m.			478,000	Hail	Hothouses, windows, and crops damaged	Do.

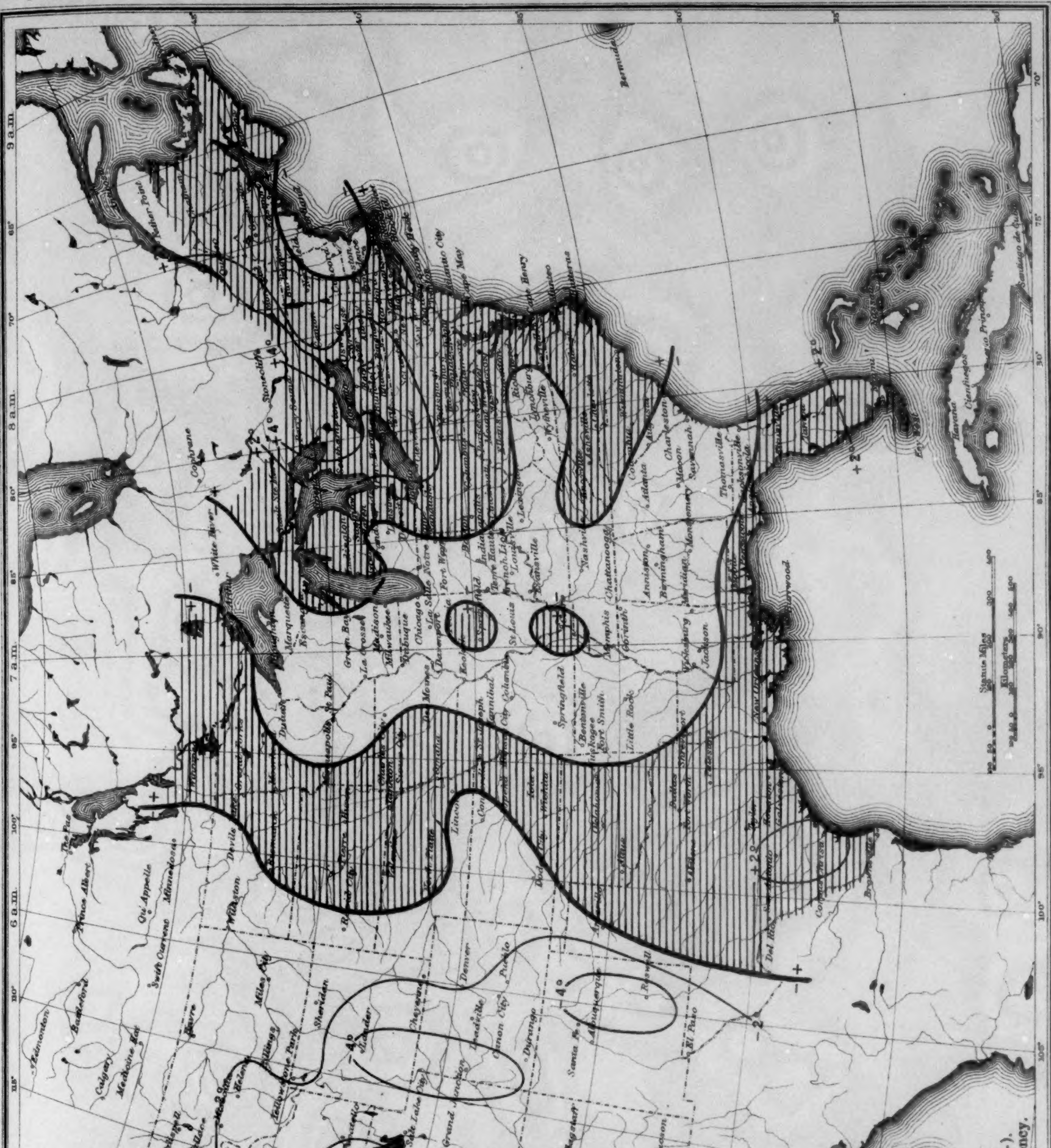
[1] Miles instead of yards.

Severe local storms, April 1933—Continued

Place	Date	Time	Width of path (yards)	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Tarrant County, Tex.	25	P.m.				Hail, electrical, and wind.	Telephone and transmission wires down.	Official U.S. Weather Bureau.
Logan, Kans.	26	A.m.				Tornado, rain, and hail.	Houses and barns demolished; trees uprooted.	Do.
Ascension Parish, La.	26	1:15 p.m.	[1] 3		100,000	Thunder, squall, and hail.	Damage to buildings and truck gardens; chickens killed; path, 16 miles long.	Do.
Atwood, Okla., and vicinity.	26	3:30 p.m.	[1] 2		6,000	Heavy hail.	Damage to crops and property; path, 12 miles long.	Do.
Panama, Okla., and vicinity.	26	4:30 p.m.	[1] 8			do.	Crop damage severe, but not estimated; path, 15 miles long.	Do.
Madison (near), Fla.	26	5 p.m.			5,100	do.	Property and crops damaged.	Do.
Clear Lake, Okla., and vicinity.	26	5-6 p.m.			21,500	do.	Loss mostly to crops, some property damage.	Do.
Natchitoches Parish, La.	26	5:10 p.m.	[1] 8		1,000	do.	Damage to cotton, corn and gardens; windows broken; path 20 miles long.	Do.
Scott to Jefferson Counties, Ark.	26		[1] 6-7		100,000	Hail	Few persons injured; property damaged.	Do.
Texarkana, Tex., and vicinity.	26	7:30 p.m.	150	5	14,000	Tornado	38 injured; many homes damaged or destroyed; small crop loss.	Do.
Greenville, Miss.	26	11 p.m.			10,000	do.	Property damaged.	Do.
Arkadelphia and Hot Springs, Ark., and vicinity.	26				32,000	Heavy hail	Lighting systems, gardens, and other property damaged.	Do.
Montrose, Pine Bluff and Sheridan, Ark., and vicinity.	26				85,000	do.	Damage to greenhouses, crops, and property.	Do.
Waldron, Ark.	26				500	do.	Damage to gardens, truck, and buildings.	Do.
Poteau, Okla.	26				600	Hail	Loss to crops; property damaged.	Do.
Bokoshe, Okla., and vicinity.	27	4:30 p.m.			4,000	Wind	Property damage $4,000; loss to crops unestimated.	Do.
Livingston Parish, La., western portion.	27	5:30 p.m.	2,200		6,000	Heavy hail	Loss to strawberry and bean crops.	Do.
Monticello, Fla.	27	5:45 p.m.	[1] 6			do.	Loss of crops considerable; several barns blown down and stock killed.	Do.
Kentwood (near) to Ponchatoula, La.	27	8:45-9 p.m.	[1] 2		100,000	do.	Damage to truck; path 30 miles long.	Do.
Geismar and Gonzales, La., and vicinity.	27					Tornadic winds, hail and rain.	3 houses blown down, strawberry plants shredded; windows broken.	Do.
Clayton, N.Mex.	28	4 p.m.			4,000	Tornado	2 airplanes demolished at airport	Do.
Oxford, Fla.	28	6 p.m.	[1] 4			Heavy hail	Considerable damage to crops	Do.
Howey In The Hills, Fla.	28	7 p.m.	880		25,000	do.	Fruit growers suffered loss; crops damaged.	Do.
Zellwood (near), Fla.	28	9-10 p.m.				Hail	Crops, especially melons, severely damaged.	Do.
Umatilla, Fla.	28	9:30 p.m.				Heavy hail	Largest damage to melons and citrus fruits; melons destroyed and crop delayed 4 weeks.	Do.
Orlando (near), Fla.	28	10:30 p.m.	[1] 1		12,000	do.	Damage mostly to crops; tomatoes in some fields total loss.	Do.
Phillipsburg, Kans.	28	P.m.				Tornado	Considerable damage to trees and small outbuildings.	Do.
Hammond and Ponchatoula, La., and vicinity.	28		[1] 1		750,000	Hail	Many strawberry fields ruined, others damaged 50 percent.	Do.
Cherokee and Crawford Counties, Kans.	29	10-11 a.m.	[1] 3		40,000	Wind	Telephone and power lines blown down; farm buildings damaged; many windows broken; path 13 miles long.	Do.
Henderson (near), Tex.	29	3 p.m.	100		10,000	Tornado	12 persons injured; path 10 miles long.	Do.
Anderson County, Kans.	29	4:30 p.m.	50		5,000	do.	Farmhouses and other buildings damaged or demolished; many chickens killed; path 16 miles long.	Do.
Noma (near), Fla.	29	5 p.m.	2,640			Heavy hail	Severe damage to crops	Do.
Leavenworth County, Kans.	29	5:30 p.m.	880		10,000	Tornadic winds	Damage chiefly to telephone exchange; roofs and trees also damaged; path 1 mile long.	Do.
Wyandotte County, Kans.	29	6 p.m.	[1] 5		27,500	Hail and wind	Crops destroyed and thousands of windows smashed; automobiles damaged; some persons injured; path 15 miles long.	Do.
Camp Joy, Ark.	29	7 p.m.			3,000	Tornado	Path narrow and short	Do.
Bourbon County, Kans.	29	do.	300-400		50,000	do.	Damage chiefly to farm buildings; no injuries reported; path 4½ miles long.	Do.
Conway, Ark., 11 miles southeast.	29	10 p.m.			1,000	do.	Property damage; path narrow and 1 mile long	Do.
Greenville, Miss. (½ mile south).	29	11:15 p.m.		1	25,000	do.	Property loss; 15 persons injured	Do.
Sioux City, Iowa	29	P.m.			1,000,000	Heavy rain	Damage to property	Do.
Little Rock, Ark.	29				6,000	Wind	Poles and trees blown down; property damaged.	Do.
Missouri, northern half	29					do.	Poles and trees blown down; small damage to buildings.	Do.
Southeastern Arkansas and western Mississippi.	29-30			6	500,000	Tornadic winds	Much property damage; 1,000 persons homeless	Do.
Grand Rapids, Mich.	29-30					Electrical and gale.	Telephone cables and poles blown down; 2 houses struck by lightning.	Do.
Yazoo City, Miss.	30	1 a.m.		3	500,000	Tornado	40 persons injured; property damaged.	Do.
Plato Center, Ill., and vicinity.	30	Noon	100		30,000	do.	Telephone and power service destroyed; high school wrecked; other property damaged; path 2½ miles long.	Do.
Milwaukee, Wis.	30	1:57-2:05 p.m.			10,000	Electrical and hail.	Damage to property, mostly windows; cellars flooded.	Do.
Durand & Pepin Counties, Wis.	30	3 p.m.			5,000	Tornado	Several porches torn off, roofs damaged; other property loss; path 2 miles long.	Do.
Lake City, Mich., (5 miles east).	30	6 p.m.	65		10,000	Tornado and hail	12 to 15 buildings, wrecked; no loss of life or serious injury reported.	Do.
Churubusco, Larwill, Troy, and Richland, Ind.	30	P.m.				Wind and hail	Frame barn blown down; damage mostly to greenhouses.	Do.
Warsaw and Kosciusko Counties, Ind.	30	do.				Heavy rain and hail.	Windows in greenhouses broken; basements flooded, damage to gardens; livestock killed.	Do.
Garnett, Kans. (west of).	30	do.				Tornado	Property damaged; large number of chickens killed.	Do.
Northern Illinois	30					Wind, rain, and hail.	Much damage and temporary floods	Do.
William and Hardin Counties, Ohio.	30				20,000	Wind and hail	Property damaged	Do.

[1] Miles instead of yards.

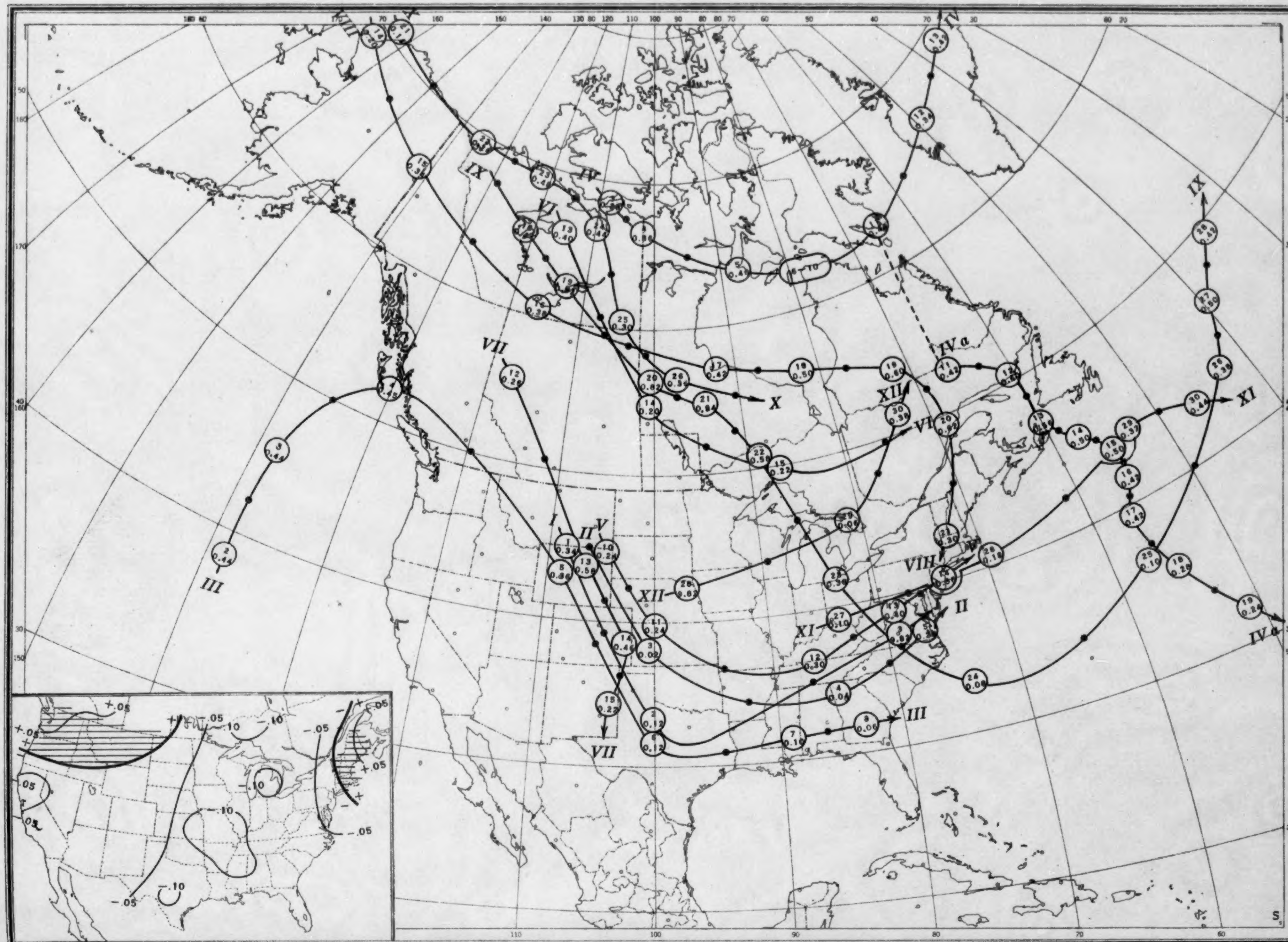
Chart I. Departure (°F.) of the Mean Temperature from the Normal, April, 1933



Shaded portions show excess (+).
Unshaded portions show deficiency (—).
Lines show amount of excess or deficiency.

Chart II. Tracks of Centers of Anticyclones, April, 1933. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by G. E. Dunn)

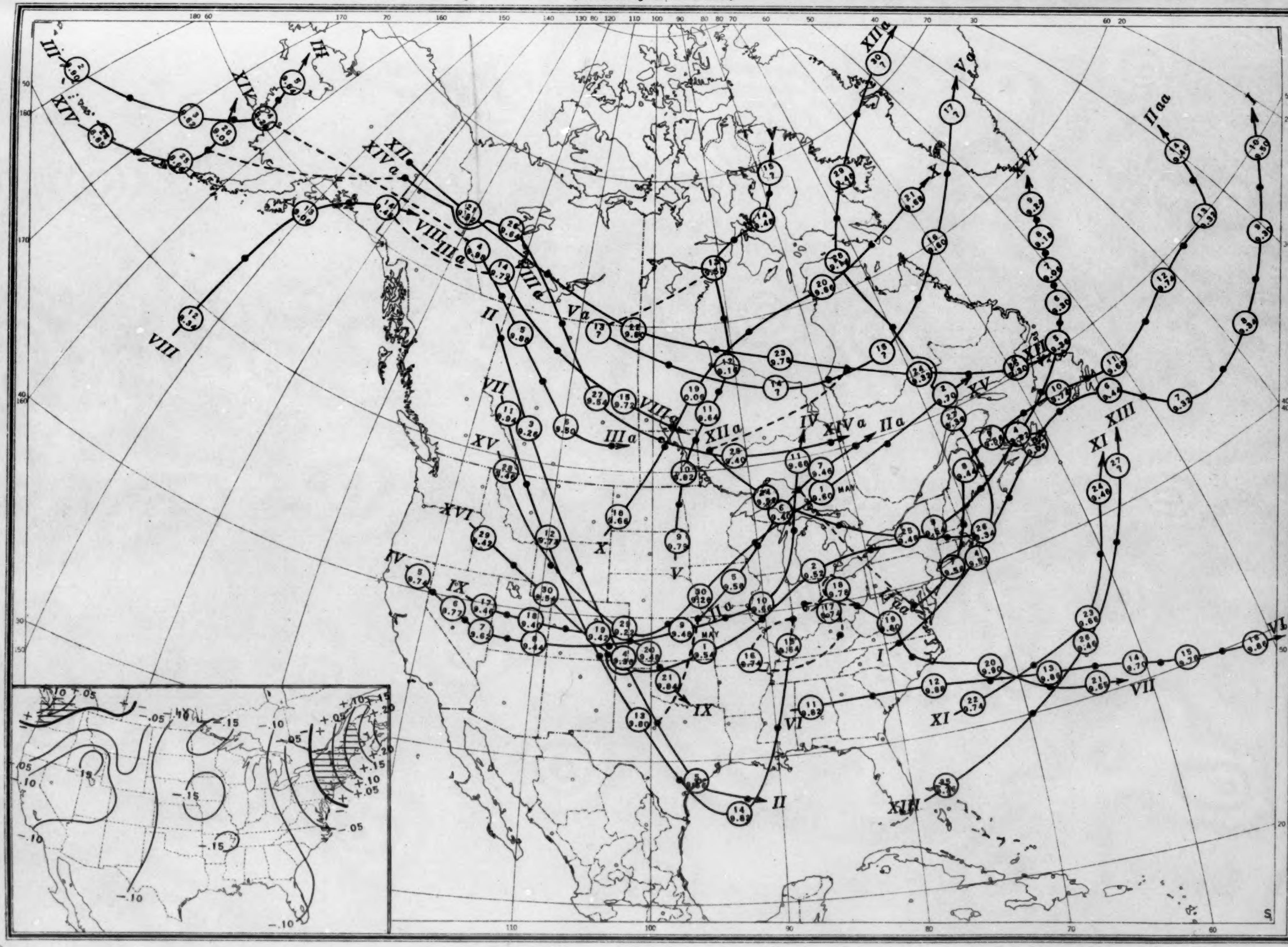


Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Circle indicates position of anticyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 8 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, April, 1933. (Inset) Change in Mean Pressure from Preceding Month

(Plotted by G. E. Dunn)



Circle indicates position of cyclone at 8 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 8 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky between Sunrise and Sunset, April, 1933

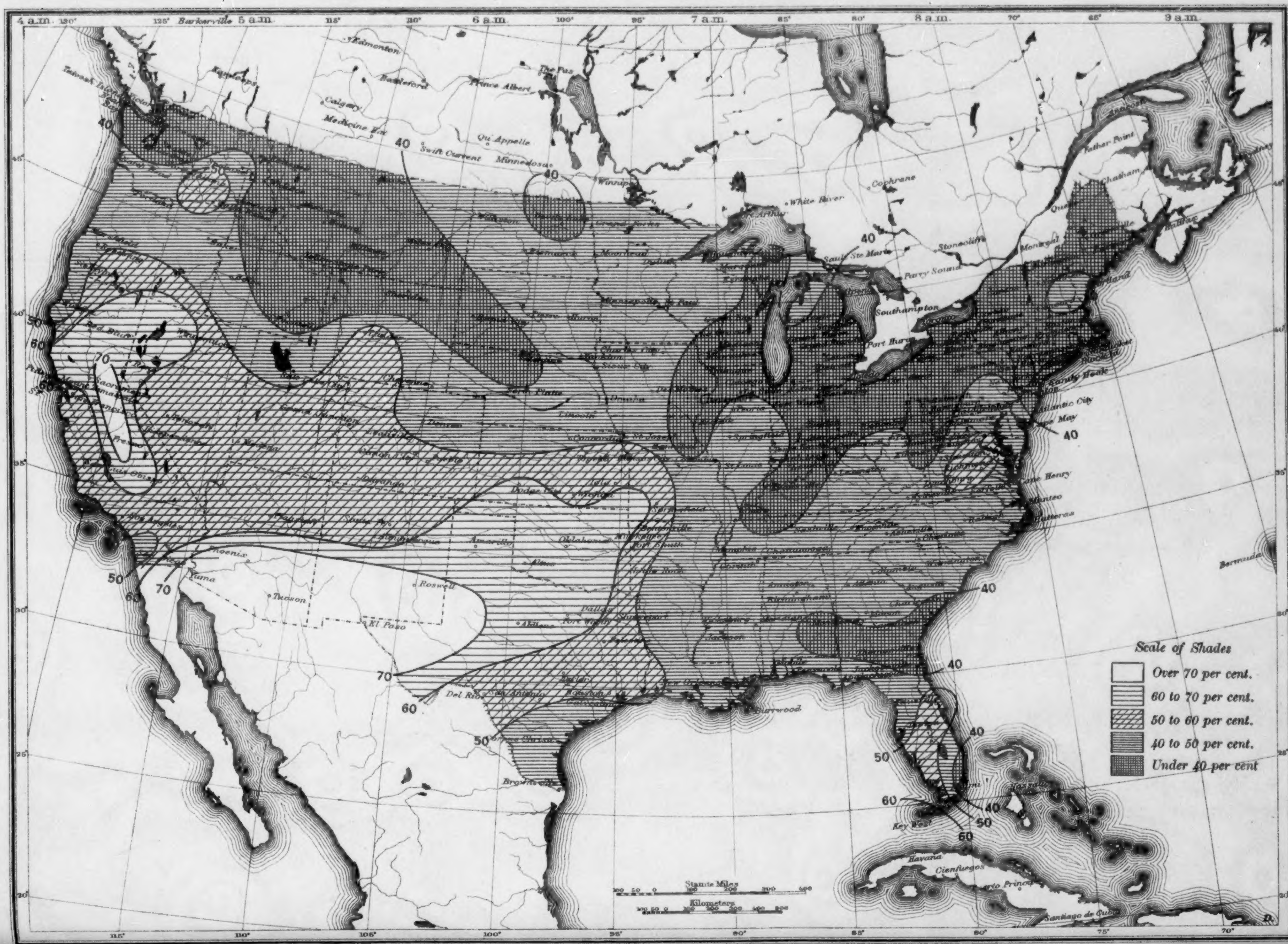


Chart V. Total Precipitation, Inches, April, 1933. (Inset) Departure of Precipitation from Normal

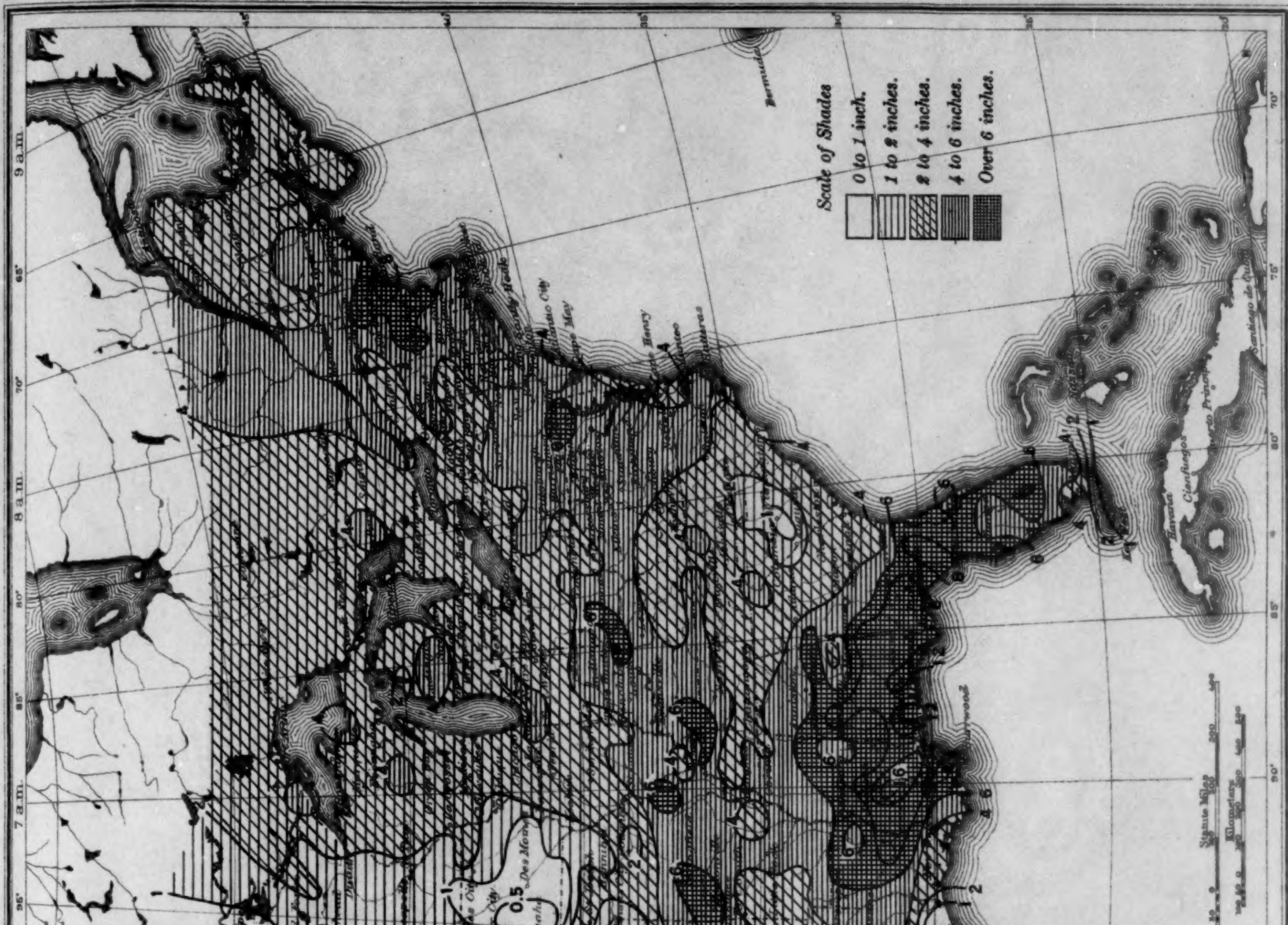


Chart V. Total Precipitation, Inches, April, 1933. (Inset) Departure of Precipitation from Normal

Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, April, 1933

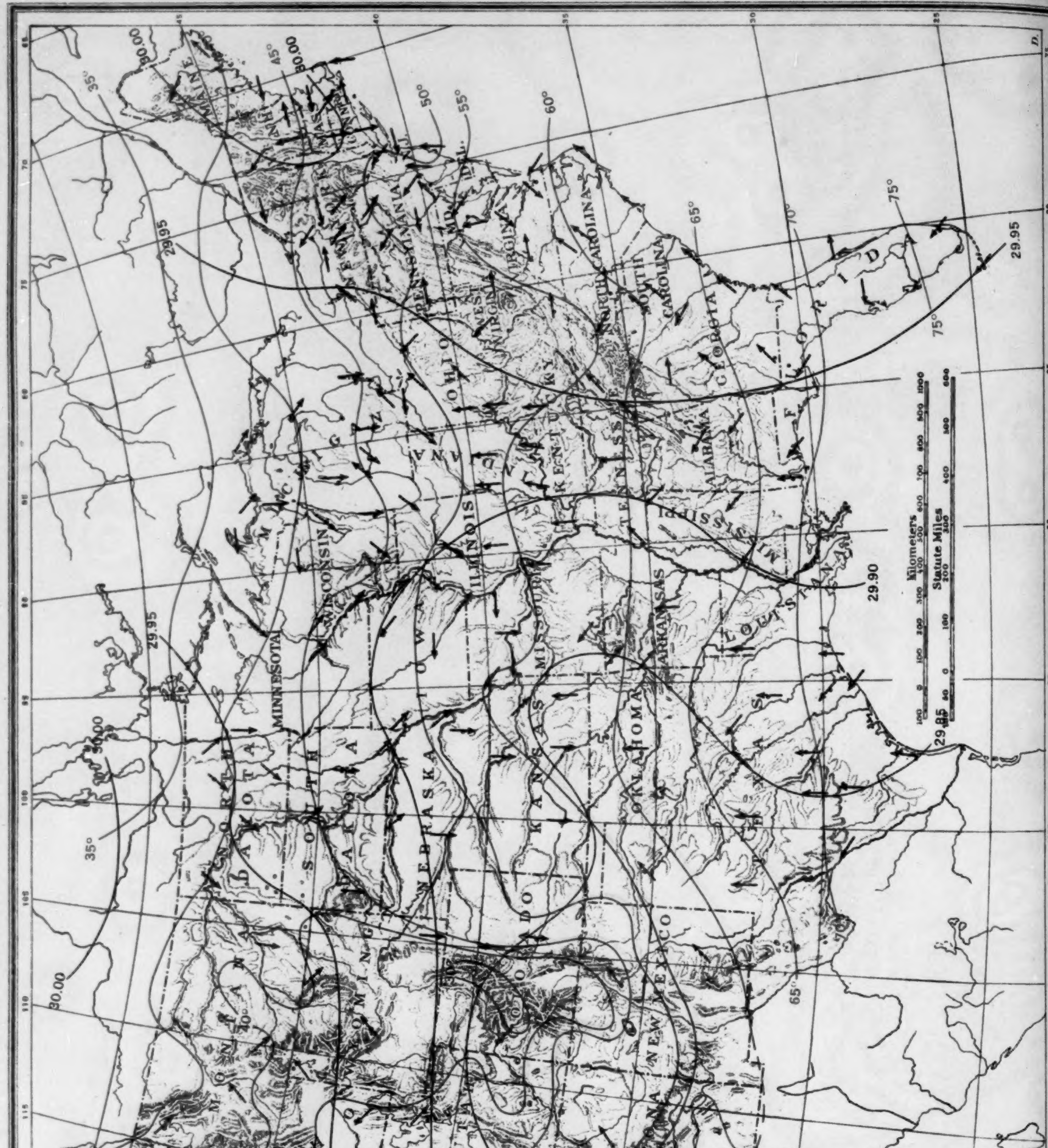


Chart VII. Total Snowfall, Inches, April, 1933

Chart VII. Total Snowfall, Inches, April, 1933

Chart VIII. Weather Map of North Atlantic Ocean, April 3, 1933

Chart VIII. Weather Map of North Atlantic Ocean, April 3, 1933

(Plotted from the Weather Bureau Northern Hemisphere Chart)

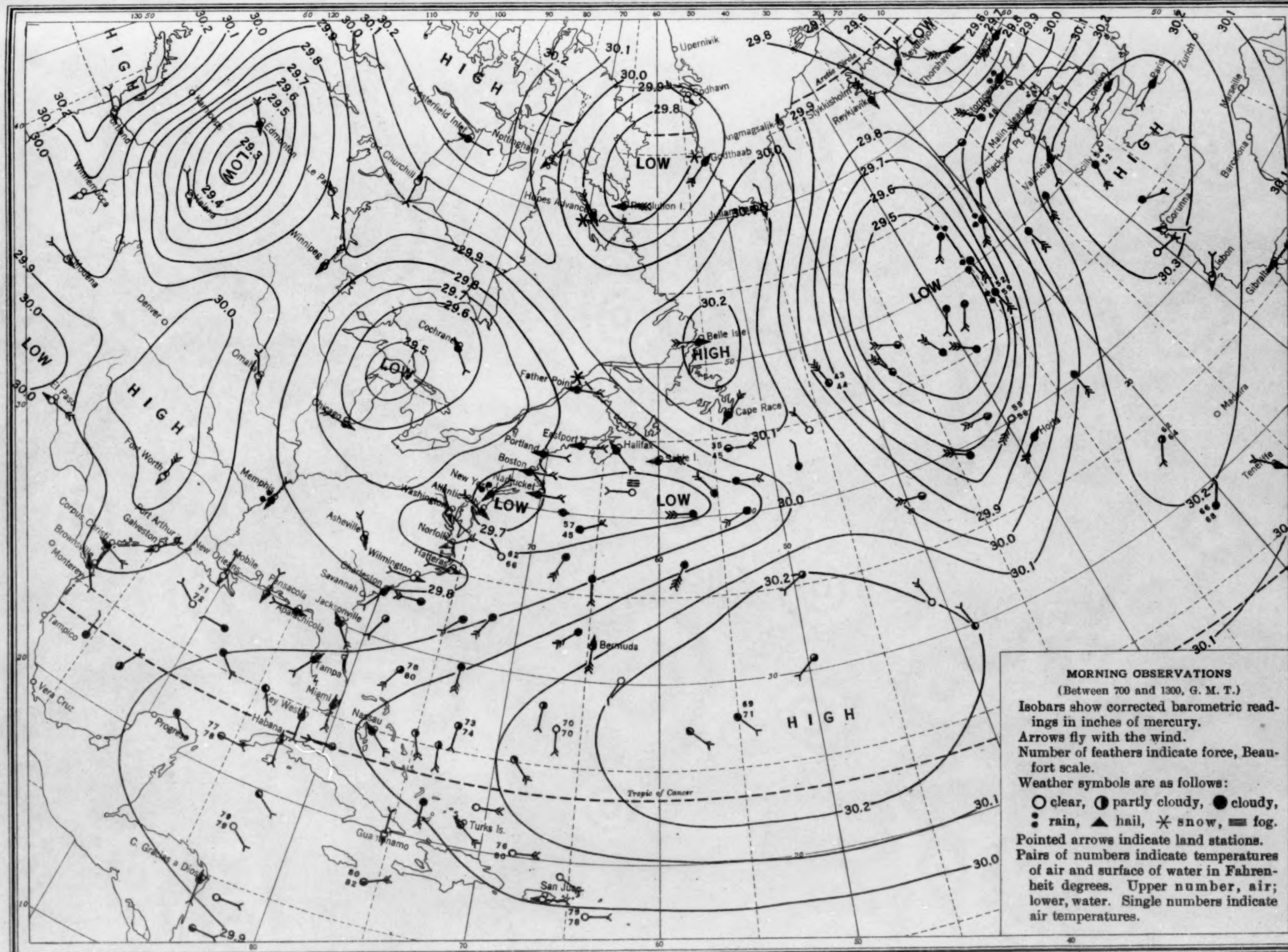


Chart IX. Weather Map of North Atlantic Ocean, April 4, 1933

(Plotted from the Weather Bureau Northern Hemisphere Chart)